MANUAL ON THE CONSERVATION OF PAINTINGS

INTERNATIONAL MUSEUMS OFFICE

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ERRATA

This manual was printed in the summer of 1940, *that is at a critical period of the war and, in the circumstances, it was impossible to correct the final proof-sheets. Below will be found a list of printer's errors and we rely on the indulgence of our readers for those which may still have escaped our notice.*

Page 7 : line 13 — for *smokes* read *smoke.*
Page 8 : line 21 — for *plaking* read *flaking.*
Page 16 : line 7 — for *casel* read *easel.*
Pages 32 and 33 : Figs. 2 and 3 should be reversed.
Page 35 : line 5 from bottom — for *sometime* read *sometimes.*
Page 69 : line 3 from bottom — for *conditions* read *condition.*
Page 77 : line 14 — for *improvemente* read *improvement.*
Page 108 : line 6 — for *fiedl* read *field.*
Page 136 : last line — for *surafce* read *surface.*
Page 154 : line 3 — for *phenomeon* read *phenomenon.*
Page 159 : line 3 from bottom — for *instances* read *instance.*
Page 172 : last line — for *ayer* read *layer.*
Page 193 : line 5 — for *photrogaph* read *photograph.*
Page 248 : line 18 — for *afte* read *after.*
Page 252 : line 2 — for *correspoads* read *correspond.*
Page 260 : line 2 — for *picturos* read *pictures.*
Page 267 : line 14 — for *museums* read *museum.*
Page 267 : line 26 — for *radling* read *cradling.*
Page 267 : line 30 — for *oparations* read *operations.*
Page 270 : line 18 — for *nouveaus* read *nouveaux.*
Page 276 : 3rd. division downwards — for *June* read *Jaune.*
Page 278 : line 2 from bottom — for *Cinnaber* read *Cinnabar.*
Page 282 : column 5, division 4 from bottom, for *Indibofera* read *Indigofera.*
Page 283 : line 3 — for *ultremarines* read *ultramarines.*

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EDITORIAL COMMITTEE

FOREWORD

Before we enter upon a practical study of the problems with which this manual deals, it is necessary to recall the circumstances to which it owes its origin and in which it was compiled. In so doing, we shall indicate the needs which its authors have endeavoured to meet and the particular class of readers to whom it is addressed.

In carrying through the programme of co-ordination which it had set out to accomplish, the International Museums Office had, from the very outset, given special prominence to the important question of the conservation of works of art. Its preliminary investigations, consultations and conversations had clearly revealed that systematic studies on this subject were being pursued in many laboratories and scientific institutes, but that the problems raised by the upkeep and reconditioning of artistic treasures entrusted to the safekeeping of museums could not be solved without close international collaboration between savants—physicists and chemists—on the one hand, and fine art experts—curators and historians—on the other. It was with a view to preparing the ground for such a system of co-operation that the International Museums Office convened an International Conference in Rome, in 1930, to discuss the scientific methods employed for the examination and conservation of paintings. The idea of holding this conference had been suggested by two members of the Directors' Committee of the Office: M. Daniel Baud-Bovy, President of the Swiss Federal Commission on Fine Arts, and Professor Richard Graul, former Director of the Art Museum of the City of Leipzig.

The exchange of views which took place on the occasion of this first contact between laboratory experts, museum curators and art historians made it possible to establish valuable data regarding certain points and to delimit the spheres in which it was desirable to continue the work that had thus been set on foot. Two facts, in particular, were definitely confirmed: first, that no scientific research bearing on the analysis and conservation of works of art can be successful unless the technician is in possession of the facts of style and history which only the art historian can supply; secondly, that modern science places at the disposal of curators and art historians

means of investigation and treatment which greatly facilitate the safeguarding of an artistic heritage and the enhancement of its value from the museographical standpoint as well as from the point of view of the science of the fine arts.

Among the conclusions of the experts who took part in the Rome Conference, which were published in N° 2 of the Dossiers of the International Museums Office *(1) those which directly concern us here relate to the restoration of paintings and to the composition of varnishes. The special committee appointed by the Conference to make a detailed study of these problems drew up a series of general recommendations dealing chiefly with the hygiene of exhibition buildings, the scientific examination of works of art before subjecting them to treatment of any kind, and the need for entrusting the care or restoration of paintings to a qualified staff or to an approved laboratory. For the time being, the committee limited its study of the problem of restoration to the question of varnishes. It indicated briefly the qualities and properties that should be present in the varnish layer in order that it may efficiently fulfil its functions, and suggested the model formulæ which could be adopted. To give effect to these recommendations, the special committee asked the International Museums Office to nominate a small committee whose duty it would be to prepare a manual for the guidance of museum directors and of collectors.*

In order that the work of this committee might be adequately prepared, the International Museums Office considered it indispensable to pursue the examination of these problems on the basis of the recommendations formulated and in that spirit of co-operation so strongly advocated by the Rome Conference. The members of the Conference and several other experts afforded the Office the benefit of their continuous collaboration, as is shown by the articles which it has since published and which are given in the bibliographical references at the end of this volume. This pooling of the results of laboratory research and the experience of art curators, combined with the data that could be provided by art historians, was still of too recent date to yield immediately all the advantages that could legitimately be expected of it.

This second stage in the preparatory work was of notable assistance to the committee of experts who met in Paris in 1933. It was possible to place before them definite data, besides the results of actual experiments carried out by the members of the committee and other relevant information which the International Museums Office had collected from among its collaborators in every country. Equipped with

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(1) *Documents on the conservation of paintings*, Paris, 1933, International Museums Office. Report (in French) of the discussions of the committees of experts of the Office, completing the recommendations and conclusions contained in this manual.

this material, the committee was able to draw up a plan for the Manual and, at the same time, to specify its scope and purpose. It accordingly agreed upon a detailed plan for the work and suggested the points that should be emphasised by the authors, as well as the supplementary consultations and further collaboration that would have to be arranged in order to complete the documentation already assembled by the International Museums Office. The discussions which took place at the meetings of this committee were also published in the above-mentioned Dossier N° *2.*

Shortly before this committee met, various national fine art departments and directors of the leading museums had asked the International Museums Office to prepare a short pamphlet for the use of their staffs, setting forth the most important practical principles to be observed for the rational conservation of works of art in museums. The Office was able to meet this request with the help of the material which it had collected and the results of the discussions held by its experts. The pamphlet was prepared in collaboration with the Paris committee and distributed to the various institutions concerned (1).

The plan of the present manual and the class of readers for whom it is primarily designed show clearly that the International Museums Office does not propose to limit the work which it has undertaken regarding the conservation of paintings to a single publication. In collaboration with its experts, with the laboratories attached to the leading museums or fine art departments in the different countries, and with the various educational authorities, it will continue to study the problems relating to the technique of painting and the composition and manufacture of colours as subjects of instruction in fine-art schools. The conservation of paintings cannot, indeed, be confined to the upkeep and restoration of works of the past. Present and future works must be given that physical quality which will save them from deterioration, many cases of which are due to faulty composition of the constituent elements of the picture or to inappropriate technique.

This manual, which, as stated above, is intended essentially to serve as a guide for curators and collectors, should not be regarded as a treatise for the use of restorers. The upkeep and restoration of works of art—and this point will be repeatedly emphasised in the following pages—are definitely the work of specialised craftsmen, work of a delicate character necessitating long preparation and a fairly eclectic training, for it implies not only a knowledge of history, of styles, of chemistry and of physics, but also a technical training and manual skill which cannot be acquired without the tuition of qualified masters who have at their disposal the experimental

(1) See chapter : *Practical Recommendations.*

material to be found only in important museographical institutions. For the last few years, therefore, the International Museums Office has devoted its attention to the professional training of restorers and has already collected and published the views of experts on this subject, consulting, whenever necessary, the restoration schools of some of the larger museums.

It should be noted that this Manual on the Conservation of Paintings, *which deals only with casel paintings, is the first of a series which the International Museums Office will devote in turn to the various categories of objects of art (water-colour paintings, guazzo, drawings, engravings—sculpture, ceramics,—furniture, textile fabrics,—metal objects, glassware, etc.).*

The Editorial Committee, however, considered it highly desirable that the main aspects of the problem of mural paintings should be taken up forthwith for the benefit of curators who have specimens of this class of paintings in their collections, or who may be called upon to ensure their conservation and possibly to supervise their transfer. It was in response to this recommendation that the International Museums Office decided to publish in Mouseion *(Vol. 39-40) the study which Professor E. Lavagnino had written at the request of his colleagues on the committee. The Office nevertheless has the intention of publishing, in this series of manuals, a comprehensive study on the problems arising in connection with the protection and conservation of mural decoration (frescoes, mosaic, etc.), which will be discussed not only from the point of view of the materials used, but also from the standpoint of the architectural elements on which they are executed and the setting in which they are preserved.*

It may be recalled here that after the international conference which met in Athens in 1931, the Office published a comprehensive work on the vast problem of the preservation of historic monuments. The planning and equipment of museums, which must be regarded as an indispensable factor in the rational conservation of works of art, also formed the subject of a museographical treatise, based on the proceedings of the international conference held in Madrid in 1934. The memoranda submitted to this conference and the discussions which took place furnished the authors of this manual with invaluable material, particularly on such matters as the heating and ventilation of museums, exhibition furniture, etc.

This brief review of the origins of this manual was necessary in order to explain the scope and purpose of its various chapters. It is the result of sustained collaboration between savants, curators and historians and gives a general view of the present position of research in all countries into this vast question of the conservation of works of art. It is strictly limited to the methods which have proved successful in

actual practice, but it takes into account the most authoritative opinions. It does not claim to lay down any hard and fast rules to be observed by restorers, but, with all the authority attaching to the names of the experts who have collaborated in this work, it suggests the principles that should be borne in mind by curators and collectors who are anxious to ensure the most healthy surroundings for their treasures and who wish for guidance as to the expediency or efficacy of the treatment that may be required for the works of art entrusted to their care.

Yet, the International Museums Office does not consider that its work, even in this special field of the conservation of paintings, is ended by the production of this manual; the results of the experiments that are still being carried out will later supplement the data contained in various chapters; new methods of treating paintings may prove to be successful; further investigations will serve to clarify a few specific points. It will be for the International Museums Office to collect the relevant documentary material and to publish it, as it has done up to the present, so as to keep constantly up to date the available information on a subject which, particularly in recent years, has engaged the attention of all who take a wholehearted interest in the safeguarding of this inestimable artistic heritage as well as in the quality of present-day productions.

By common consent, the authors of this manual decided that their personal contribution should remain anonymous, in order to make quite clear the collective character of the work presented and the joint responsibility of all for the opinions expressed. A full list of the names of the numerous collaborators, outside the committee, who have rendered invaluable assistance in the compilation of the volume, and of the studies which they have communicated to the International Museums Office, will be found in the bibliographical appendix.

Finally, the International Museums Office wishes to express its gratitude to the members of the Editorial Committee for their valuable and disinterested collaboration, as well as to all the museum curators, collectors, scholars and technicians who have so generously contributed to one or other of the chapters of this work.

E. FOUNDOUKIDIS.

PART ONE
CONSERVATION

CHAPTER I

GENERAL PRINCIPLES APPLYING TO THE CONSERVATION OF PAINTINGS IN MUSEUMS

As the writer of the foreword points out, this Manual is intended chiefly for curators of museums, to serve as a guide in the choice of methods for the conservation of the works in their keeping. The curator is not necessarily a professional restorer, but he must be in a position to check the work of the specialist to whom he has entrusted a picture. In other words, he must have some idea of the general principles underlying restoration. He is usually neither a professional architect nor an engineer, but he must be able to satisfy himself that the conditions of the premises where the pictures are hung are quite suitable for the effective conservation of these objects. These two points will be discussed in a very general way in the present chapter and studied in detail in the two parts of the Manual entitled "Conservation" and "Restoration".

The conservation of works of art in museums may be studied by following them from the time of their acquisition to the stage when they are hung.

1. — As soon as the picture arrives, its state of conservation should be scrupulously examined by the methods set out in the following chapter. Should deterioration, retouching or repainting be revealed, very delicate questions crop up that involve not only material study but quasi-moral considerations. In connection with these questions, the curator must have a very clear idea of the importance, requirements and significance of any picture exhibited in a gallery.

A work of art that takes its place in a collection of some importance thereby assumes a certain scientific and social significance that any curator should make it his duty to encourage to the fullest extent of his competence and conscience. This means that every operation performed on the picture must be conditioned by scrupulous honesty with regard to the scholars who will refer to the work and the public who also can be very exacting as to the genuineness of what is put before them. Every art gallery director and every restorer knows how difficult it is to carry out this twofold task. And instead of compromising be-

tween scientific punctiliousness—which would treat a master's work as though it were a biological culture—and the requirements of visitors—who go to the museum to look at works that are complete and alive—the curator will sometimes choose the simpler course of distinguishing between "public" and "scientific" works. But setting up a study collection and a public collection cannot by any means account for every case, just as the public cannot be divided into the initiated and the profane. And the curator who respects his social responsibilities wants as many people as possible to avail themselves of the treasures in his museum.

General Principles.

2. — These seemingly contradictory requirements have, however, one point in common when it is a case of restoring a deteriorated picture—the æsthetic aspect or the "effect" of the picture. An art historian may, in a different way from the uninitiated spectator but nevertheless to a considerable extent, be put off in the appreciation of his senses or even the judgment of his intelligence, by a patch of deterioration on a painting. We must here establish a distinct difference between *gaps* in a painting and mutilations in sculpture. The absence of an arm or a head—to mention only specially famous instances—does not necessarily destroy the effect of a statue. The eye often supplies the missing part without difficulty, or even dispenses with it and experiences no more discomfort than it would before a sketch that suggests more than it expresses. On canvas or wood, on the other hand, the missing element is a positive factor with colour and shape that can be made up for by the imagination only with the very greatest difficulty.

3. — What should the restorer do in such a case? Several methods have been advocated. The most scientific, and also the most elementary, consists in choosing a neutral tint that matches the surrounding colour to cover the bare patch on the support. Carrying the method somewhat further, it has sometimes been thought advisable to extend the design over the defective area, using one or two colours that match the surrounding paint but without adding any contours. Then there were advocates—fewer and fewer nowadays—of complete restoration. Between these extremes, there is, of course, a whole series of methods and it would be rash to choose any one of these, as there are three fundamental points to be taken into account—the importance of the work, the

position of the deteriorated patch on the subject and the skill of the restorer. In other words, it must be realised that each case has its special treatment and that no cut-and-dried doctrine holds good for all. Generally speaking, more tact is needed when the work is that of a master; although for such works there are often sketches and studies available to act as a reliable guide for the restorer. If the deterioration is localised or away from the principal subject, the picture may be *completed*, without incurring too many risks, either scientific or æsthetic.

4. — In conclusion, it may be said that any form of restoration, backed up of course by full scientific knowledge, should enable the spectator to look at the work without being distracted by any definite addition, though the restoration should be visible under scrupulous examination. Another practical point— restoration should always be carried out with materials that can be removed at any time by means of a substance which does not attack the original painting. Lastly, under no pretext should a fragment, however small, of the original paint ever be covered in retouching.

These technical precautions and the safety measures that precede any kind of restoration (photographic records, analysis of pigments, binding media, etc.) are dealt with in separate chapters of this manual.

We would mention here, however, that, apart from the records in document form that should accompany any kind of restoration, whenever a work of art has undergone treatment, the fact should be regularly mentioned in the scientific catalogue of the museum. Whenever such treatment distinctly changes the character of the picture, as compared with its previous aspect, this fact might also be mentioned in the short catalogue. In a popular guide to the museum, such an indication would naturally be superfluous.

The general idea is not to arouse the mistrust of the public by systematically hiding the real condition of a picture; the other extreme is equally to be avoided, for the uninitiated might easily make unpleasant generalisations and jump to the conclusion that the gallery contains no truly genuine pictures.

5. — Retouching and repainting of a later date than the original work raise problems of technique and style much the same as those created by deterioration or gaps. When such treatment has been revealed by scientific examination, the curator must decide just how far the picture that has been retouched or "improved" must be restored to its original state. Here again there are no stock recipes, as everything depends on the nature and extent of the repainting

the degree to which it has altered the original and (the most important point) the curator's ability to estimate the advantages and risks of removing it. All these points should be cleared up before any action is taken. The question of gaps needed the combined skill of the restorer and the art historian, but the latter's advice becomes a *sine qua non* when a decision has to be made on whether retouching should be removed or left. A scientific examination will show how far the underlying paint is capable of standing the operation and the curator and the expert will have to form their own judgment, taking into account the risks that might be incurred and the advisability of the treatment. It is here more than ever essential to keep records of the various stages of development of the work, before, during and after treatment (1). Other repairs or operations that may be necessary are more obviously of practical interest only and will be dealt with in the chapters on technique. This does not mean that problems of cleaning, the removal of varnish and re-varnishing, whole or partial transfer, re-lining and other methods of strengthening can ever be tackled purely materialistically. All these operations may not only alter the appearance of the picture but may often involve risks of which the restorer should make it his duty to inform the curator.

6. — The restorer has another duty to fulfil, even when the picture does not call for immediate treatment. Acquainted as he is with the various inter-reactions of the elements that make up a picture, he should be asked by the curator to draw up a diagnosis of the state of conservation and resistance of the pictures hung in the gallery and define the right atmospheric conditions to keep the works protected from subsequent deterioration. Periodical inspection of every collection is essential. Visits of inspection should be more frequent in the case of works that are specially threatened and should take place regularly at the change of season, when the heating is turned off or on, for instance.

7. — This question of the hygiene of the premises needs very special attention by the curator. At the request of numerous Fine Art Administrations, the International Museums Office once drew up a circular describing in detail the more urgent steps to be taken to protect paintings from the risks of all kinds to which they are exposed in an art gallery. These recommendations, which are

(1) A method that has been tried out in the central restoring studios in Moscow (see *Mouseion*, Vol. 27-28, pp. 228 *et seq.*) would seem, in the case of certain ikons, to enable the different layers removed during the freeing of the bottom layer to be conserved.

reproduced in the Appendix to the present volume, form a sort of *vade-mecum* for the use of curators and their staffs.

It may be objected that not every museum possesses the means and equipment to carry out to the letter every operation required for the rational conservation of pictures. Yet even under the most unfavourable practical conditions—defects in the building, primitive heating system, unhealthy climate, and so on—there are a whole series of precautions that may be taken in order to remedy these disadvantages to some extent, if the action of external agents on the elements that make up the picture be accurately known. It has been one of the objects of the authors of the present manual to offer the curator a detailed account of the structure of pictures, as revealed by the most up-to-date discoveries of experimental technique, so that he may be able to decide for himself the best methods of preserving his collections in the premises at his disposal and with the means of cleaning, heating, ventilating and lighting provided by the design and equipment of his museum.

It is obvious that, the more rudimentary his installation, the more carefully must the curator attend to the hygiene of his premises and acquaint his staff with all the precautions required to avoid accidents, such as too brutal ventilation, draughts, over-heating, method of cleaning the floors and so on. On the other hand, the most perfectly fitted out museum demands careful supervision, especially in the case of works just acquired. For the question of climate and acclimatisation—and the point cannot be over-emphasised—is of vital importance to the "health" of any work of art. Modifications in the hygrometric conditions—for this is what a change of climate amounts to—are the most responsible factor of deterioration. It will be seen later in this work that there exist optimum standards for the effective conservation of pictures, but just as the human organism is in danger when suddenly transferred to a climate which is quite healthy from the medical point of view but quite different from the one it is used to, so pictures that have been exposed for a long time to a very damp or very dry climate suffer serious damage when suddenly removed to even a normal climate. The curator will therefore endeavour, as far as possible, to obtain accurate information on the antecedents of the work he acquires, in order to get it gradually accustomed to the climate of the district and the premises. For this purpose, if he has no equipment for air-conditioning, he will choose one of the rooms in his museum that offers the most suitable conditions. Steps to be taken for the transport of pictures or for temporary exhibition (which raise similar problems) will be studied in a special chapter.

The same precautions must of course be taken when a new heating plant is installed. Whatever system is chosen, the change will necessarily entail new hygrometric conditions and the curator must study ways of smoothing over the change as far as possible. To do this, he may make tests on works of less value, which the restorer will be asked to watch over a period that must be fairly long.

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These considerations and recommendations are naturally not exhaustive. We merely wished to indicate the right attitude towards methods of preserving irreplaceable documents and to draw the curator's attention to the points that require his special help in this work of preservation, his professional responsibility being at stake.

CHAPTER II

METHODS OF INVESTIGATION APPLIED TO THE EXAMINATION OF PICTURES

General Principles.

8. — An easel painting consists of a series of layers of different materials, all more or less intimately fused together: varnish, picture-layer, ground and support (panel or canvas); and each of these layers may, under a well-conducted examination, afford information which is important to an understanding of the nature, origin and condition of the work.

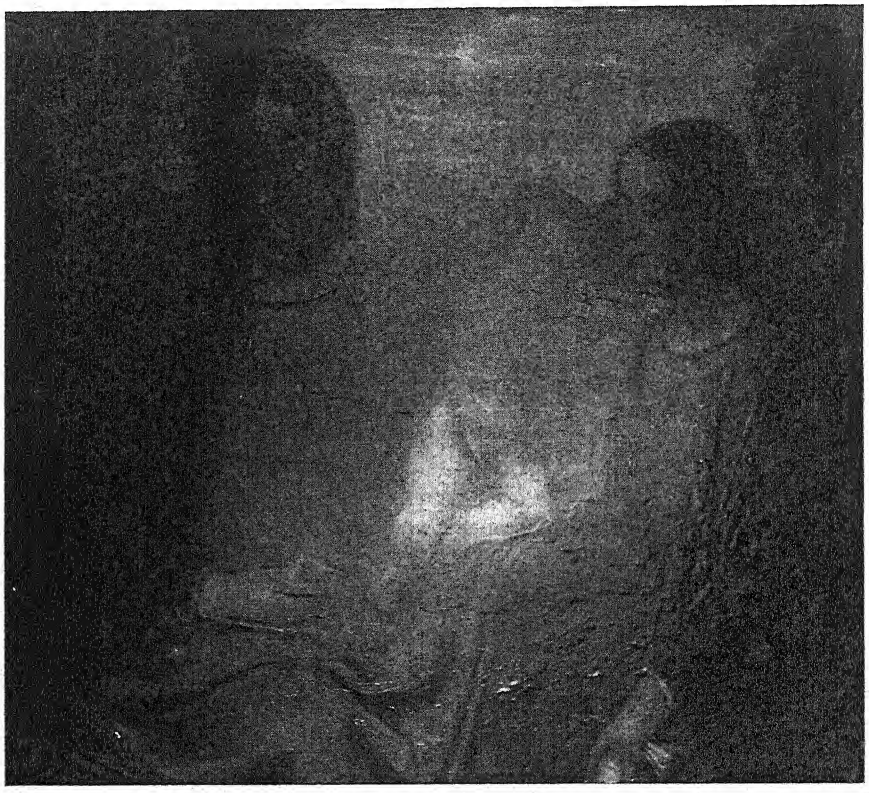
From the museum point of view, methods of examination fall into two categories:

A) Those methods which can be applied within the gallery at small expense by the curator;

B) Those methods which require more specialised equipment and the services of a technical equipment.

Such a differentiation is obvious and necessary but insufficient without further qualification because, although in the first category there are processes (such as photography by infra-red radiation) which might be applied, they have no place in the general examination. And it must be obvious that, from the point of view of the collection, a systematic method of recording the main features of a picture is likely to be of infinitely more value than isolated observations of a more specialised character.

The present chapter has been planned therefore in accordance with what it is considered should be the requirements of the curator: *a*) to have guidance in the method of carrying out a routine survey of a painting, and *b*) to have sufficient data before him regarding specialised methods, which are outside his normal routine but which may be invoked in order to answer some particular question concerning the painting or its structure. These specialised methods are always subservient to his researches and are only applied when occasion



1. XVITH CENTURY ITALIAN PAINTING PHOTOGRAPHED BY REFLECTED LIGHT; THE DETAILS OF THE FIGURES ARE INDISTINCT BUT SURFACE TEXTURE (BLISTERS, ETC.) IS STRONGLY EMPHASISED.

demands. They, in turn, can be subdivided into methods which can be applied direct to the picture and those which can only be applied to samples taken from the picture.

Finally, one cannot over-stress the importance of collecting the results together on a standard record-card or case-sheet which is available for immediate reference and comparison of data. The accumulation of systematic records is not only of immediate utility but of historical importance.

As an example of the variety of useful information which can be established by simple means, one could not do better than refer the reader to the Record

Card drawn up by the American Association of Museums (1), to the Information Card used by the *Schlesisches Museum für bildende Künste*, Breslau (2), and that which was suggested for adoption by the Swedish museums (3).

It goes without saying that to complete such a technical report in the case of any one picture would require the co-operation of more than one specialist, but its completion is seldom necessary. The curator will generally be content with something less ambitious, though, from his point of view, not necessarily less valuable, and it will give him satisfaction in proportion to the care he expends in his examination and in the accurate description of his observations.

The record will naturally be of importance when restoration becomes necessary, and, indeed, when a valuable painting requires the attention of a restorer, no cleaning, preventive or curative measures are embarked upon without considering the history of the picture as furnished in the technical description. Before any treatment is applied, the existing notes should be brought up to date and supplemented if necessary by sketches or photographs.

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(1) See *A Museum Record of the Condition of Paintings*, Technical Studies, Vol. 3, 1934-35, pp. 200-216.

(2) See *Mouseion*, Vol. 20, pp. 23-25.

(3) See *Mouseion*, Vol. 25-26, pp. 220-225.

A. GENERAL METHODS OF EXAMINATION APPLIED TO PICTURES

Preliminary Survey. — Examination by the naked eye.

9. — The question of lighting is of the first importance in all forms of optical examination. Standard conditions of light assist the eye to appreciate and interpret detail. Quality, intensity and direction of illumination are all of importance.

Preliminary examination is usually conducted in a strong (natural or artificial) daylight, and this provides information as to the general condition of the picture. Direct sunlight is even more effective in this respect, and it often reveals more to the unaided eye than examination in a poor light, even with the help of magnifiers.

With the old adage in mind that "a picture cannot reflect more light than it sees", one places the easel so that oblique rays entering through the window strike upon the painting from the greatest expanse of sky, leaving room for the observer intermediately. The orientation is important, and the effect of various adjustments in this respect should be examined.

If a daylight lamp be employed, it should be of such a nature as to provide an intense beam adjustable in any direction.

The general condition of the picture having been assessed and recorded, the next step is to examine the surface in detail under three distinct conditions of lighting. Auxiliary artificial illumination will be required for this part of the investigation, which may be carried out conveniently in the photographic studio.

1. *Normal Lighting* : Light rays at right angles to the surface of the picture (Fig. 2).

2. *Oblique Lighting* : Light rays incident at about 45° from one side of the painting (Fig. 3).

3. *Tangential Lighting* : Light rays striking the picture at a very oblique angle, throwing into the highest relief all surface unevenness, brushwork, etc. This method often shows at once the position of stoppings and retouchings (Fig. 1).

In each of these three cases, the observer is assumed to be stationed immediately before the painting. In the second case, he may be able to see more surface detail by standing in the path of the reflected light (Fig. 1).

When studies are carried out according to this routine, facts emerge which enable the curator to decide upon what further general investigation is required. This, indeed, is the main object of the preliminary examination.

As the work proceeds, one naturally makes photographic records and sketches of the salient features, under the conditions which show them to best advantage.

For these studies, it is desirable to equip one end of the studio with lamps which can be adjusted to the standard positions in accordance with the three systems mentioned, and the photographer is then called upon as required. *A note of the exact lighting conditions must in all cases accompany observations and photographs.*

It is perhaps not sufficiently appreciated that the appearance of light and shade on the surface of an oil painting can sometimes be completely reversed by changing from normal to oblique illumination. This point is well illustrated in Figs. 2 and 3.

Subsidiary Aids in making a General Survey of a Picture. Use of Magnifiers. Varying the Intensity of Light.

10. — Smaller areas are studied only in their relation to the picture as a whole, and it follows that the use of magnifying apparatus must be considered as supplementary to the preliminary examination. If a further reason is required, it is that comparisons by the unaided eye are instinctive, whereas with optical equipment a certain familiarity is essential if the personal factor is to be so far eliminated as to yield results which are easily interpreted.

The stronger the magnifier the smaller the field of view, the nearer it is to the painting when focused, and the more intense must be the lighting. But the light must not be too intense or there will be a loss of detail.

One of the best types of lamp for studying small fields is the Leitz Monla lamp, provided with a condensing lens and a carrier for colour filters. This operates at 6 volts 5 ampères and may be overloaded to 6 ampères without risk of blowing. Possible damage by heat rays can be guarded against by keeping the lamp at some distance from the picture, ensuring that the condenser is adjusted for parallel rays and limiting the time of exposure. When the rays must be focused on a tiny area of paint, one introduces a special glass screen between the lamp and the picture in order to filter off the heat rays.

The actual type of magnifier may now be considered. Low magnifications are of most general utility. Magnifying spectacles are sometimes used, but

2. MASTER OF THE LEGEND OF MAGDALEN, PHOTOGRAPHED IN NORMAL LIGHT; BLISTERS ARE NOT APPARENT UNDER THIS LIGHTING.

3. THE SAME PICTURE PHOTOGRAPHED UNDER RAKING LIGHT; ALL SURFACE IRREGULARITIES APPEAR IN STRONG RELIEF.

there can be no doubt that the handiest equipment consists of a series of double-lens magnifying glasses which yield a flat field of view. The following gives some indication of the features which can be recognised on the picture and of the subjects which can be studied under low magnifications:

Lenses magnifying ×2-×3 *diameters:* Small details, brush-work, signatures, etc.

Lenses magnifying ×6-×10 *diameters:* Detection of fine retouches; examination of the pureness of craquelure, etc. (As is well known, one of the most frequent questions in examining pictures is as to whether the original craquelure is covered by later painting or not).

A lens of ×8 diameters is very useful for studying framed pictures whilst on exhibition; the glass of the picture-frame prevents one from getting near enough to use a stronger lens.

Magnifications of ×10-×15 *diameters:* Used for studying superimposed layers of paint, depth of craquelure, etc.

For observations up to ×30 diameters, binocular magnifiers have a number of advantages: they do not cause eye-strain; they give a larger field of view and they present objects in their natural relief. It is also a material advantage for those not ordinarily engaged in microscopic work that the image presented is neither inverted nor left-and-right reversed.

Magnifications of ×20-×30 *diameters:* Used for studying odd particles of pigment, etc. A rigid support for the binocular is required when studying objects above ×10 diameters, and for work on pictures the most convenient form of stand is one which will allow of angular adjustment of the binocular from the vertical to the horizontal position. Absolute rigidity is essential if the camera is to be used with the binocular to record interesting features as they are discovered. A special camera of light weight can be obtained to clamp on to one eye-piece of the binocular (e.g. the Leitz "Lukam" camera).

Photographic Records.

11. — It is sometimes argued that photographic enlargement from small negatives gives results which are quite as satisfactory as those obtained by direct enlargement. This is found, in practice, not to be the case. Better and clearer pictures are obtained as follows:

1. *Low magnifications* (below ×10 diameters). An enlarged picture is made using a suitable lens in an ordinary camera having bellows which allow of adequate extension.

2. *Higher magnifications* (over×10 diameters). The camera is used in conjunction with the binocular microscope, as above described.

The first method should be adopted for the general detailed study of passages in a painting when this is necessary. A series of full-size photographs (i.e. the size of the passages in the actual picture) should be prepared. The experienced student has learned to appreciate the value of being able to settle comfortably in the calm surroundings of the study, and to scrutinise these full-size photographs at leisure in an atmosphere free from the distracting influences of studio lights and the awkward poses so often called for during the preliminary investigation.

It would be out of place here to enter further into the methods of ordinary photography as applied in the general survey. It is a commonplace that a good photographer can record more detail on a photographic plate than the eye sees. He can emphasise or suppress details by his choice of plate or filter or by the adjustment of his lighting or focus, and it is essential, therefore, that he should be given guidance as to what facts are of importance, so that he can produce a good photograph of the particulars which it is desired to study.

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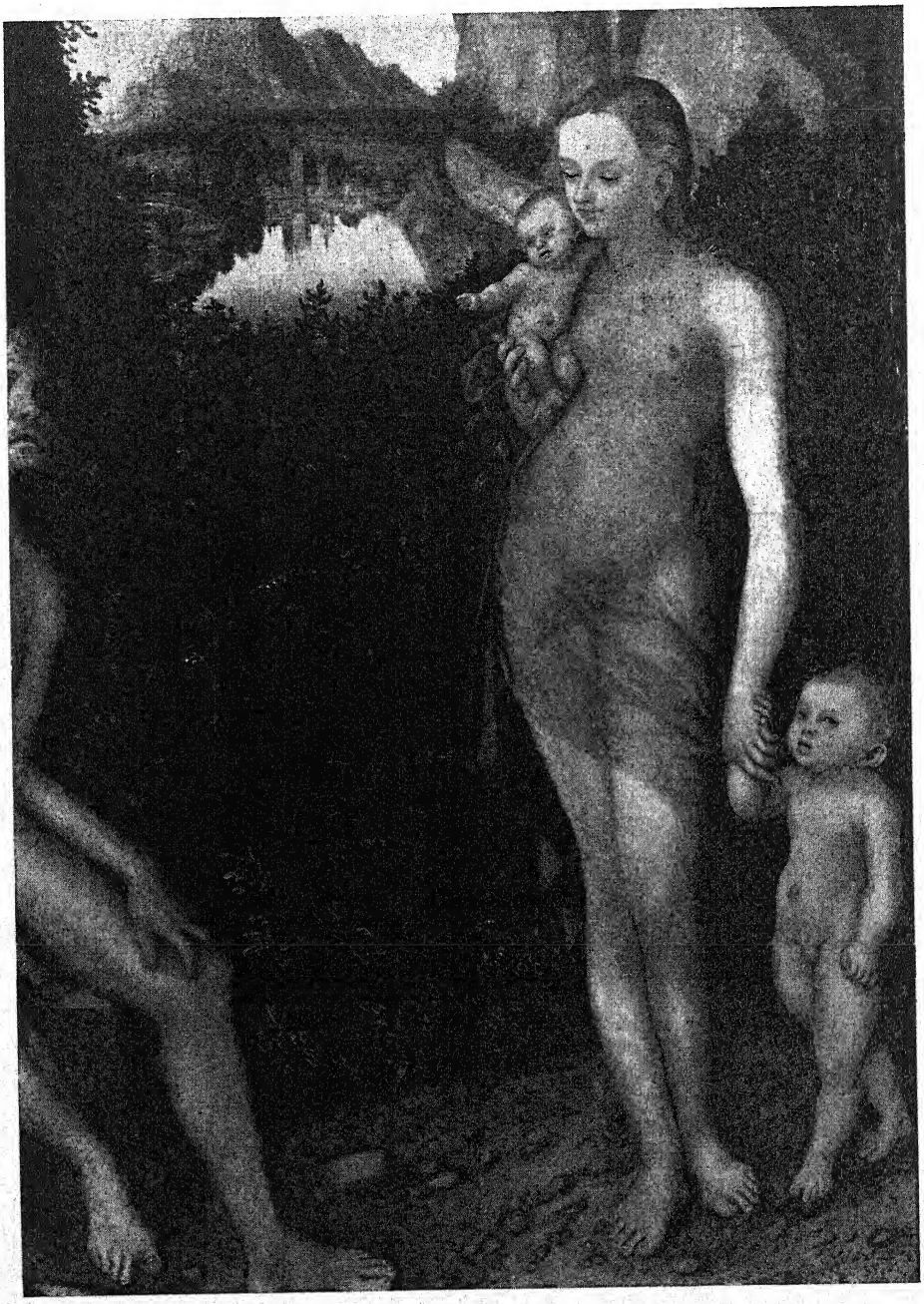
The general examination should cover not only the picture but also any reinforcements which are applied to the back (stretcher, cradling, wedges, buttons, etc.). It may be well worth while to measure, sketch and even photograph the back of a panel of complicated construction, because it sometimes happens that peculiarities of surface craquelure or blistering can be correlated with cracks in the wood panel (seen from the back) or with parts of the actual cradling which have seized or warped and, in consequence, have become a source of danger to the picture-layer.

Special cases : Dull and shiny surfaces.

12. — One of the difficulties often encountered during the examination of a painting is that details are in part obscured by an accumulation of surface dirt.

This may sometime be removed by very careful rubbing with a silk handkerchief. Pictures vary so in composition and in the stability of their various layers that it would be rash in the extreme to attempt to generalise on methods of surface cleaning. The curator would be well advised to refrain from attempting to modify the surface in any way without consulting the restorer. Even



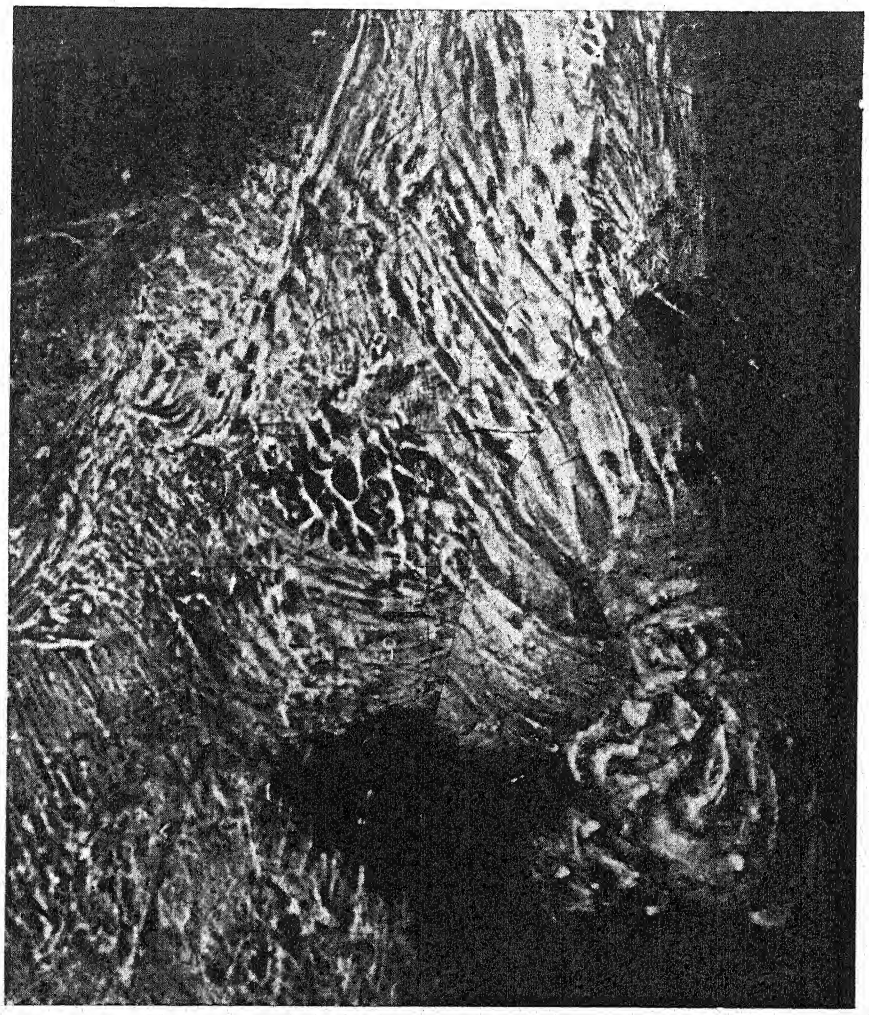
4. PAINTING BY CRANACH, AN ENLARGED DETAIL OF WHICH IS GIVEN OPPOSITE.

5. ENLARGED DETAIL OF THE CRANACH OPPOSITE. EXAMPLE OF REPAINT (HAIR AND VEIL) REVEALED BY ENLARGEMENT, THE HAIR HAS BEEN LENGTHENED IN A LATER REPAINT AND THE VEIL, PAINTED OVER THE HAIR, DID NOT EXIST IN THE ORIGINAL PICTURE.

turpentine, which is usually regarded as innocuous, may sometimes be detrimental. The common habit of using moisture (even saliva!) for making part of the picture (e.g.a signature) more visible may easily result in blooming the varnish or even in causing more serious decay.

In consequences of this kind, where sinking-in, dullness or any other change of surface conceals important data, the painting will have to be cleaned, but in accordance with the recommendations given in the chapter devoted to this question. And if it is decided that cleaning is necessary and desirable, it should be conducted with the assistance of a specialist. A photograph of the picture, taken *through* this dirt, is sometimes possible by the infra-red process.

An equally common obstacle in studying paintings is the shiny varnished surface which reflects too much light (''glare''). It is no solution of the problem of glare to recommend modifications in the direction of lighting, because the positions of lamps, etc., as we have seen, are regulated by the routine of the examination. Variations in intensity may, however, improve conditions. Where a certain modification of colour is not significant, it is possible to cut out most of the glare by introducing a depolarising screen (''Polaroid'' screen, ''Bernauer'' equipment, etc.). It must be stated, however, that such screens cut off much of the light, so that although they certainly afford a striking improvement in appearance, their use is limited. (See § 162).



6. EXAMPLE OF MACROPHOTOGRAPHY APPLIED TO THE IDENTIFICATION OF WORKS OF ART. ENLARGEMENT OF THE NOSE OF "TITUS" (REMBRANDT, 1652), ADDED TO A FRAGMENT (BELOW ON THE RIGHT) ALSO ENLARGED, OF THE SHOULDER AND ARM OF "THE ADULTERESS" (REMBRANDT, 1644). THE SIMILARITY OF BRUSH-WORK IS CLEARLY SHOWN BY THIS COMPARISON. — DOCUMENT PREPARED BY PROFESSOR A. P. LAURIE.

B. SPECIAL METHODS OF EXAMINATION APPLIED TO PICTURES

Characteristics of special methods.

13. — A purely arbitrary line is drawn between the general and the special methods of investigation, determined by the fact that, important as they are, some limit must be set to the routine observations which are regarded as a minimum necessity in the care of each picture. Having completed the general record, the observer may wish to carry his studies further.

Where the photographic studio is equipped with tungsten lamps, for example, there is the possibility of using the infra-red constituent of this light for the photographs of an appropriate subject, as described later. But having regard to the specialised nature of the information afforded by investigations of a purely scientific nature, the curator will be more concerned to learn of possibilities and of the facts which special methods of examination are likely to disclose, than to be burdened with the intricate technical details of scientific manipulation.

Having discovered, from the results of general examination, whether there are any important points outstanding which still require elucidation, it then becomes necessary to select from the many special methods of the physicist and chemist, a process likely to afford the desired information.

Such methods may be broadly classified as follows:

I. *Methods applied direct to the picture* (Photography by X-rays, ultra-violet rays or infra-red rays. Colorimetry, crystal structure analysis and microscopy).

II. *Methods applied to samples taken from the picture* (Microscopic studies of materials. Chemical and spectrographic analysis. Refractive index determinations).

I. — Methods applied direct to the picture

X-Rays.

14. — *Visual examination: Radiology.* — When X-rays are passed through a painting in a darkened room, they are in part absorbed by the constituents of the various layers of the picture, and when the emergent rays strike a fluorescent screen a shadow-reproduction is observed on the screen, which looks somewhat like a photographic negative. This is the method of "screening" or radiology. The image has often something of the character of the original picture, only with greater contrasts. The reason is that the lighter portions of the picture

7. RADIOGRAPH OF A XVTH CENTURY DUTCH PAINTING, SHOWING THE FIBRES OF THE WOOD AND THE HARMONY BETWEEN THE FIRST WHITE-LEAD MODELLING AND THE PAINTING ITSELF.

are generally in white lead, often painted thickly, and white lead stops the rays and so is reproduced on the fluorescent screen as a dark patch.

The Radiograph or Shadowgraph. — When a photographic plate (or film) is substituted for the screen, the process is known as *radiography*. This sensitised surface is affected by the rays passing through all the layers of the picture and not least by the pigments themselves. The image thus reproduced affords a permanent record of the skeleton of the paint-layer of the picture, upon which is superimposed any feature of the under-layers which is sufficiently characteristic (dense enough) to be recorded. Retouches, being mostly of thinner print, do not generally show up in the shadowgraph, except sometimes as a light veil. So if some visible portion of the picture does not show up on the shadowgraph, it is to be considered whether it may possibly be a later addition. The greatest caution is, however, necessary in attempting to draw conclusions. Even the most experienced radiologists will not always be able to decide whether such an addition may not, in fact, have been made by the original artist himself.

Again, an original sketch on the ground which does not correspond with the painting is sometimes discovered by X-ray photography. It may be impossible to decide by the X-ray method alone whether the artist was himself responsible for the lack of correspondence between painting and sketch, or whether the superimposed painting was actually the work of some later hand. The interpretation of radiograms of paintings is still in an early stage of development, but it has already led to many discoveries. It is occasionally found that a canvas or panel-painting has been completely over-painted, and steps have been taken to remove the surface layers without considering all the possibilities, in the hope of revealing a greater masterpiece, but not always with justification, as events have proved. (See Figs. 24, 46-49).

There is perhaps a tendency today to overrate the usefulness of X-rays in researches of fine art, the difficulty of interpretation being insufficiently appreciated. But as to the value of the method in skilled hands and with appropriate apparatus (giving soft rays of the order of 20 KV or less), there can be no question; it provides a potential source of securing information which might otherwise never come to light. This much has been established by exhaustive tests: that the picture itself suffers no deterioration by the radiations.

8. EXAMPLE OF UNDERPAINT REVEALED BY RADIOGRAPHY: TWO LOVERS IN THE GIORGIONE STYLE EXECUTED AT THE BEGINNING OF THE XIXTH CENTURY ON AN EARLY XVITH CENTURY VENETIAN PANEL REPRESENTING A " MAN IN SORROW ".

Ultra-violet Rays.

15. — One of the most convenient sources of ultra-violet rays is the high-pressure self-starting electronic discharge-tube of quartz giving a mercury arc, which operates in any position. This instrument emits a large variety of radiations visible and invisible, and all of these, except the ultra-violet rays, are shut off by interposing some special kind of filter. The commonest form of filter is a dark glass (Wood's screen), the emergent rays being then almost invisible. These are the so-called ultra-violet rays, and they have the property of causing certain substances to appear fluorescent when examined before the lamp in a darkened room: thus, varnishes usually appear brightly fluorescent, whilst binding media and pigments often glow in different colours, and this gives an indication of their distribution on the painting.

How used. — As a preliminary, the picture is inspected in the rays of the screened ultra-violet lamp, preferably after the eyes have had a few minutes to become accustomed to the darkness of the room, and during the examination a daylight lamp may be switched on occasionally for purposes of comparison. If the painting shows by a differential fluorescence of the surface that there are facts worthy of permanent record, such as a repainted passage or signature which fluoresce characteristically, a photograph may be taken in the darkened room by ultra-violet illumination; it is usually found that an ultra-violet photograph (luminogram) records fluorescence effects with even greater contrast than seen by the naked eye (Figs. 11, 12, 25).

Special problems for which suited:

Differentiating painting materials (materials which are of similar appearance by daylight may appear quite distinct under ultra-violet illumination, e.g. white lead is light grey, while zinc-white appears yellowish).

Revealing stoppings and over-paintings.

Studying the impurities (foreign materials) in craquelure.

Showing the extent of mould growths. (Fungi often fluoresce brilliantly).

Helping to read labels normally illegible.

Revealing finger-prints.

Limitations and precautions. — The commonest difficulty is the masking effect of a fluorescent varnish, and when there is an appearance as of a white veil over the picture, it may be necessary to have the varnish removed before any of the characteristic fluorescence of the painting can be seen.

The lamp may be used unscreened for photography if a suitable filter is introduced into the lens system of the camera.

When unscreened, the lamp has a considerable heating effect. It is advisable, on this account, to speed up the photography by using the largest stop which the subject allows and hypersensitive plates in the camera.

Avoid any unnecessary exposure of the skin to the rays, and protect the eyes by glass goggles when examining a light-coloured subject.

Interpretation of results. — It is important to remember that a luminogram is primarily a record of surface effects which may be due to traces of material —not necessarily to the principal constituents of the picture. A surface soiled by dust or grease may fluoresce comparatively brilliantly; hence the occasional appearance of finger-prints (old as well as modern) and peculiar effects due to contamination of various kinds.

The luminogram must be studied alongside the original painting and, in doubtful cases especially, every possibility probed before a reliable interpretation is attainable. An ultra-violet photograph is very useful as a record of retouches and stoppings which are to be removed by the restorer, but it is never safe to assume that all stoppings are recorded by the rays or that all patches on the photograph are stoppings. The lamp seldom yields more information about a picture than can be detected by the experienced investigator during the critical examination in the ordinary way, but it gives results comparatively quickly.

Infra-red rays.

16. — The method of infra-red examination is purely a photographic process and, given a suitable source of illumination, depends on the use of a filter in the camera which will pass infra-red whilst excluding the other forms of radiation. Special photographic plates are required, coated with an emulsion sensitive to the longer wave-lengths. The light source may conveniently be a battery of tungsten-filament lamps.

How used. — The ordinary photographic technique applies if the lens is of the type corrected for infra-red work.

After focussing by visible light, a dark red (I.R.) filter is inserted in the lens system and the exposure made. An infra-red safe-light-screen is required for the dark-room lantern.

Special problems for which suited. — As the investigation of pictures by infra-red photography has been developed comparatively recently, it is not yet pos-

9. NORMAL PHOTOGRAPHIC PRINT OF A FRAGMENT OF AN OLD DUTCH PAINTING. THE REPAINTS ARE BARELY VISIBLE.

10. SAME FRAGMENT PHOTOGRAPHED BY X-RAYS. THE GAPS IN THE OLD PRIMING ARE PARTICULARLY CONSPICUOUS, BUT THE RETOUCHINGS APPEAR ONLY AS VAGUE SHADOWY PATCHES.

sible to define the scope of the work. The most striking successes have doubtless been in revealing details in dark paint, notably in pictures which are dirty or badly bloomed. The method has occasionally given good results in the study of inscriptions. Most striking effects have been obtained where the ground is of old leather which, on ageing, may become so dense in tone as almost, if not entirely, to conceal any remains of painted decoration. Such a ground may appear quite light in an infra-red photograph.

Precautions. — The usual precautions are necessary in order to avoid overheating the picture and in drawing conclusions from the results of the examination (Fig. 26).

Colorimetry.

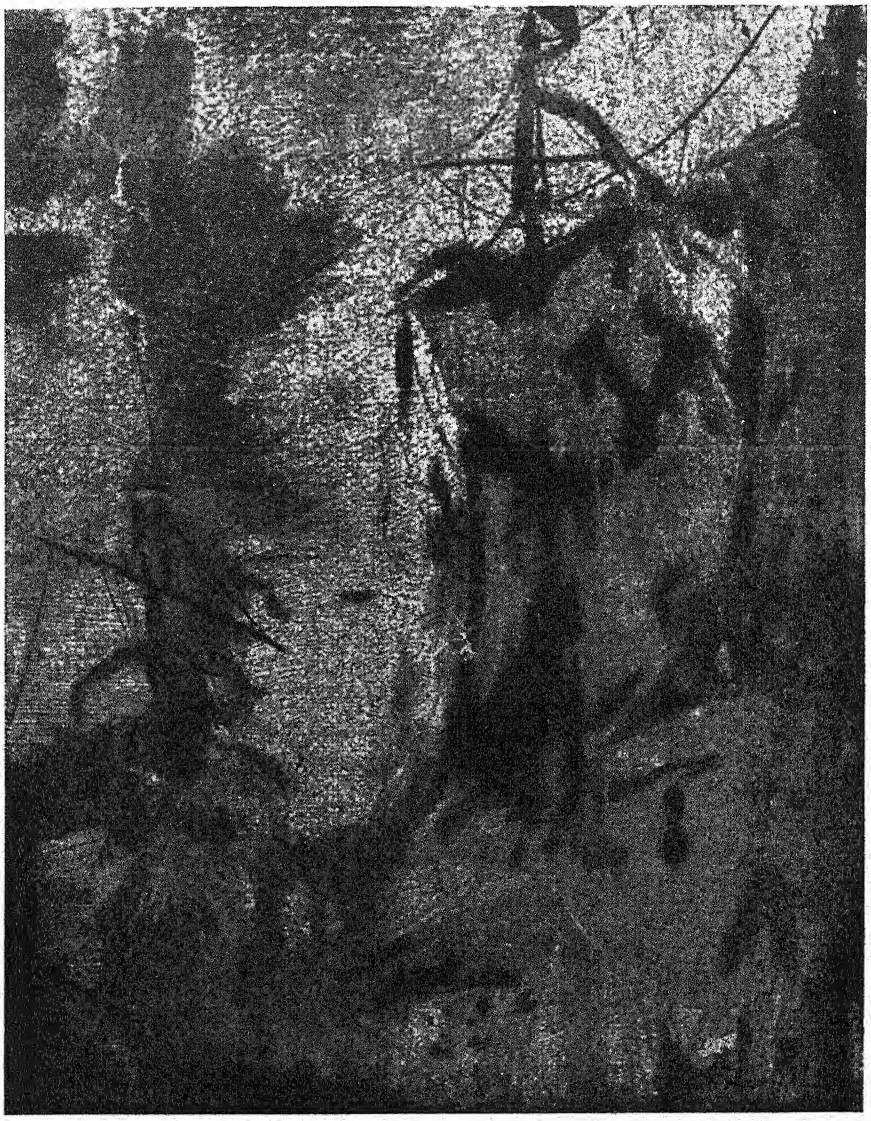
17. — The application of the photo-electric cell has been suggested in order to obtain a numerical record of the intensity of lights and shadows, readings being taken on a galvanometer. What seems a method of more practical utility is to use some form of colour change-measuring device such as the tintometer, and, by this means, colour changes which may take place, due perhaps to fading or to the depositions of dirt, may be recorded (1).

As a research instrument, the colorimeter is of value in the study of pigments and colour mixtures; it also has a potential use in some kinds of restoration work where positive evidence of the previous condition of the painting is important.

X-Ray Crystal Structure Analysis.

18. — Among the instruments used for this kind of examination we would mention the X-ray camera designed in the Research Laboratory of the Courtauld Institute of Art, London, which is a modification of the standard type of apparatus used for identifying certain pigments by photographing the characteristic pattern of the rays resulting from diffraction by crystals in the paint film of the picture. This highly specialised type of investigation has the advantage over other analytical methods that it can be applied direct to the picture in cases where it is considered impossible or inadvisable to remove the requisite sample for chemical analysis.

(1) For a detailed description of this method, see: F. Ian G. Rawlins, *Studies in the Colorimetry of Paintings, I and II*, Technical Studies, Vol. 4, 1935-36, pp. 179-186; Technical Studies, Vol. 5, 1936-37, pp. 150-156.



11. DETAIL OF THE FRAGMENT REPRODUCED IN THE TWO PREVIOUS PRINTS, PHOTOGRAPHED BY ULTRA-VIOLET RAYS (PROCESS DEVISED BY PROFESSOR MAURER, OF VIENNA). THIS PROCESS, WHICH BRINGS OUT RETOUCHINGS VERY CLEARLY, IS BASED ON THE POSSIBILITY OF REVEALING BY PHOTOGRAPHY THE CONTRASTS, INVISIBLE TO THE NAKED EYE, DUE, ON THE ONE HAND, TO DIFFERENCES IN THE COMPOSITION OF THE COLOURS AND MEDIA USED IN THE ORIGINAL AND IN THE REPAINTS, AND, ON THE OTHER, TO THE CHANGE IN THE ACTINIC POWER OF ONE AND THE SAME COMPOSITION, ACCORDING TO THE AGE OF THE PICTURE.

Microscopy.

19. — The present chapter would not be complete without some reference to methods involving the use of the microscope.

With the compound microscope and suitable objectives and illumination, one can supplement the data already obtained in binocular examination.

Provided the field is sufficiently flat and free from glare, it is possible to get good results of details of such subjects as the varnish or paint particles, or of the ground where it is exposed, up to diameters of ×100 and more. But as the possibilities are entirely determined by the type of instruments available and are generally more restricted than when a small individual sample of material is under examination, more detailed consideration may be deferred to the next section. (See also §§ 159-162).

II. — Special methods applied to samples taken from pictures

Extraction of samples.

20. — The object of sampling a picture is to study the nature and succession of each or all of the various layers. A hypodermic needle is used, sawn off and sharpened like a miniature cork-borer, and with this instrument it is possible to obtain a microscopic cylinder representing all strata of the picture. This is transferred to a glass slide for microscopic examination. The tiny hole left in the picture may easily be rendered invisible. It should never penetrate the canvas and some little skill is required in order to avoid this.

Sometimes, suitable test-pieces may be taken from the edge of a canvas or panel without the aid of the needle. Special care is then necessary to ensure that samples are truly representative and not simply fragments from later additions to the picture.

Microscopic Examination.

21. — With suitable apparatus, it is possible to measure the thickness of the various layers as well as to study their succession. The layers may sometimes be dissected and examined independently, the binding medium, oil, varnish, etc. being dissolved and removed by the use of a suitable solvent such as toluene. Pigments may be recognised by their colour, fineness of division, type of frac-

ture, etc., or by the characteristic appearance which several present when examined in polarised light.

By the methods of ordinary microscopy using transmitted light, specimens can be examined up to resolutions of about ×1000 diameters, but one is rarely obliged to have recourse to the higher magnifications. Indeed, magnifications of the order of ×100 and, exceptionally, ×250, are generally the most useful.

By the introduction of Nicol prisms, which polarise the light, certain substances may be recognised under the microscope by their depolarising properties.

Examinations conducted by reflected light are of even greater general utility because, under these conditions, the natural colour of the specimen is preserved. The great handicap is always the amount of reflected white light, which is a consequence of the bright illumination required, and this can only be overcome satisfactorily by the use of a specialised microscopic equipment designed to give critical illumination by light which is polarised. One of the best types of microscope for work either direct on paintings or on particles removed from them, is the Leitz "Ultrapak", provided with a polarising attachment for the light, and a "Monla" lamp. This effectively eliminates glare and makes it possible for work to be done with dry objectives up to magnifications of ×500 diameters with normal oculars. It provides brilliant definition for photomicrography. For other purposes, one may replace the "Monla" lamp by an arc lamp having tungsten-cored carbons; such an arrangement requires, as a necessary addition, an intermediate cooling system in order to protect the objective lenses of the microscope and the specimen under examination. The insertion of a Wood's screen between the arc lamp and the objective system cuts off the visible rays and the micro-specimen can then be studied by ultraviolet radiation. This is the process of fluorescence microscopy, a highly specialised development which is destined to prove of value in the study of painting materials.

Of the many problems which may be solved by microscopic investigation, it must suffice to mention only one, which nevertheless is extremely important and one of the commonest: the study of craquelure in the region of an inscription. If the continuity of the lines of the inscription is broken by the craquelure, the inscription may be shown to be as old as the rest of the paint; whereas if the painted lines of the inscription are seen to be inside the depressions of the craquelure, the inscription must of necessity be of a later date then the craquelure.

The facts may sometimes be rendered apparent by the use of a hand lens;

sometimes the higher powers of the microscope are required, or even the use of the microscope with ultra-violet radiation described as fluorescence microscopy. If a falsification of the kind exists, it should be detectable by one or other of the special methods of enquiry already described.

X-Ray Crystal Structure Analysis.

22. — This method, which is of limited application but of the greatest value for the identification of crystalline substances, depends on the conception of the crystal as a definite pattern of molecules in space; the crystal gives rise to a characteristic diffraction pattern on a sensitised photographic film when it is bombarded with X-rays in a special form of camera. The pattern produced on the film provides a powerful method of analysis and identification, even when only a minute grain of crystalline material is available for study.

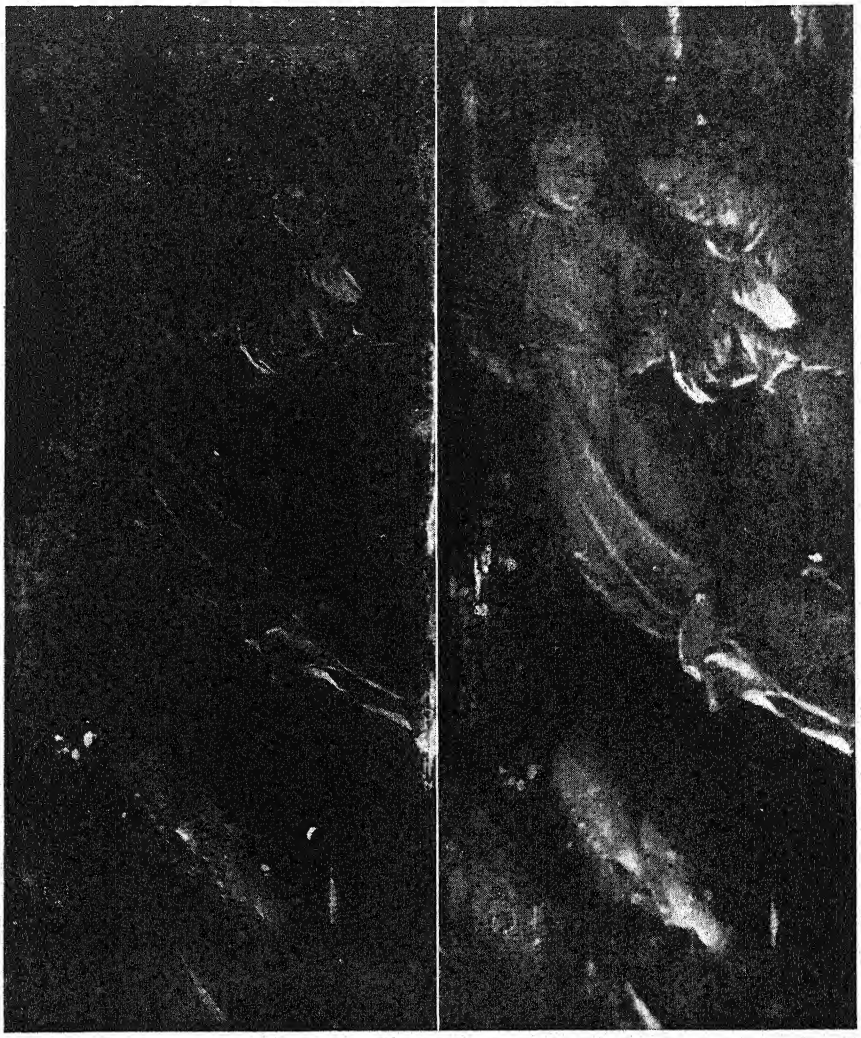
When it is possible to apply the method to a separate sample in this way, results are obtained which lend themselves more readily to interpretation by direct comparison with standards than in the modification of the process already referred to, which operates directly on the picture. Furthermore, the sample is not lost in the process of testing as is the case in chemical and spectrographic analysis.

Microchemical Examination.

23. — Historical and chemical studies of the pigments used by artists throughout the ages have occupied the attention of various workers, and, as a result, it has been established when certain pigments first made their appearance on the artist's palette and which were favoured by certain schools. (See Chapter XIII). Information on such matters is not only of importance to the history of art, but when pigments can be recognised by chemical or other means, this may provide conclusive evidence in detecting falsifications or in recognising repainted passages; and to know which pigments are present in a painting may even help with the more specialised problem of determining authorship.

As a general rule, in chemical analysis, a substance must be isolated before it can with certainty be identified. If only a tiny fragment is available for analysis, the isolation of the required material from the foreign constituents which are invariably present will still further reduce the sample, which must then be dealt with by the so-called microchemical methods.)

Microchemical processes involve a particular manipulation technique and



12. DETAIL OF A XVITH CENTURY FLEMISH PAINTING, PHOTOGRAPHED BY NATURAL LIGHT.

13. SAME DETAIL PHOTOGRAPHED WITH A MERCURY-VAPOUR LAMP, WITHOUT FILTER.

the use of a compound microscope. Results are obtained and conclusions drawn by observing some change in the material that occurs when it is brought into contact with a specific reagent. The change is commonly a colour change and often depends on the formation of characteristic crystals which can be recognised.

Pigments are grouped according to colour, and any pigment of a group can be identified by systematic testing, which eliminates all others from that particular group, except the one under examination; the routine having at length suggested to the operator the probable nature of the pigment under examination, it remains to apply a specific test which will confirm his conclusion (1).

Spectrographic Examination.

24. — Only a few milligrams of material are required for the spectrographic examination of a sample containing metallic constituents, and the result is a pattern of lines on a photographic plate, which indicates the presence not only of the principal constituents of the sample but also of metallic impurities which may be present only in traces.

Qualitative results may be obtained by this process with speed and certainty in the form of a permanent record.

In one sense, however, such a complete record may be confusing in giving a mass of insignificant data and, indeed, it is always desirable to confirm the spectrographic evidence by microchemical analysis when enough material is available for the purpose. On the other hand, as knowledge of the subject is increased, it is possible that in certain cases, as for example in the examination of the green earths which are derived from different mineral sources, these very impurities may become of significance in giving a clue to the source of the material examined.

The methods of absorption spectrography are likely in the future to be brought to the study of binding media and of organic pigments and natural dyestuffs, and may afford a possible method of identifying materials which are difficult to deal with by simpler means.

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(1) For the fundamental principles of this microchemical method as applied to pigments used in painting materials, see F.E.C. Scheffer: *L'examen chimique des tableaux* (*Mouseion*, Vol. 13-14, pp. 93-103); A. Eibner: *L'analyse microchimique des couleurs* (*Mouseion*, Vol. 29-30, pp. 113-126); A. P. Laurie: *Un laboratoire pour l'examen des peintures* (*Mouseion*, Vol. 17-18, pp. 119-122); R. J. Gettens and G. L. Stout: *The Stage Microscope in the Routine Examination of Paintings*, Technical Studies, IV, 1935-36, pp. 207-233.

Refractive Index Determinations.

25. — The refractive index of egg tempera film has been shown to remain practically constant for hundreds of years, whereas that of the linseed-oil film suffers a gradual increase of remarkable regularity (1).

The method which depends on the extraction of the binding medium from a micro-sample of the paint film and upon its subsequent examination with a refractometer has proved useful in the detection of repainting and of unusual painting media, and for distinguishing egg tempera from oil; it is also claimed that where linseed-oil has been used alone the refractive index of the film may actually provide some indication of the age of the picture.

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The above summary of specialised methods of investigation is in no sense exhaustive; it is merely intended to point to some of the principal lines of investigation which may yield results of interest to the art historian, and to guide curators in forming their judgment of these methods and of the data which they may be expected to provide.

Thus conceived, the scientific examination of paintings is in all cases to be subservient to the requirements of the curator whose interest lies in conservation and in the study of the artistic and technical features of the works in his care.

The limits of the general examination must be clearly defined by the end in view, namely the compilation of a case sheet for each picture which will provide all information of significance for its health and study.

When a sample of material is available for independent examination, the limits of the study are as inexhaustible as the methods of science, and it is the more important and necessary to envisage the problem and to exploit these methods in such a way as will yield results which are, in the first instance, of some artistic significance and value.

(1) Laurie: *Proceedings of the Royal Society of London*, Series A, N° 896, Vol. 159, pp. 123-133.

CHAPTER III

THE SURROUNDINGS

General considerations (cf. §§ 185 and 187).

26. — Experiments and observations in various countries have shown that although sudden violent changes of temperature may affect the structure of the component parts of a picture, changes in the water-vapour content of the air —which are moreover intimately bound up with fluctuations of temperature— are the decisive factor in the phenomena of deterioration due to the surrounding atmosphere. Such deterioration, which will be examined later in connection with the constituent parts of pictures, can be mechanical, chemical or biological: expansion and contraction of the hygroscopic matter which absorbs or exudes the humidity of the surrounding air, in accordance with the laws of equilibrium; chemical or biological disintegration of such matter, especially in the presence of water.

27. — All hygroscopic matter has a degree of elasticity enabling it, within limits, to follow the movements of expansion and contraction caused by variations in the hygrometric ratio (water-vapour content of the air measured against temperature). But it has been proved that these fluctuations, when repeated, appreciably decrease the coefficient of elasticity of the matter in question, even when they constitute only a small fraction of the strain the object can normally stand. Now paintings are always composite bodies and their different parts do not react to external agents in the same proportions: the phenomenon of expansion and contraction is thus complicated by the fact that the component parts do not expand and contract simultaneously in accordance with the same coefficient, which may lead to dissociation, distortion or breakage of the components which originally formed a whole. If the physical process of deterioration is accompanied, as is often the case, by chemical or biological action (rotting, oxidisation, dissolution, mildew, etc.), the phenomenon is even more complex. As the relative humidity is to some extent a gauge of the drying or

moistening powers of the air, it follows that a change in the hygrometric reading is a more active factor of deterioration than the customary changes of temperature (day to night, season to season, etc.). For not only does the hygrometric reading vary within wider limits, but even tiny variations in the water-content alter the size and shape of most hygroscopic matter to a greater extent than the relatively more impressive changes of temperature.

This law is confirmed by the fact that objects can be effectively protected against deterioration by a coat of wax or varnish that would be of little use against temperature changes. It follows that adequate protection depends on decreasing the process of water exchange between the object and the atmosphere.

The rules for the local protection of objects against hygrometric variations will be explained in other chapters; the problem we must attack here is the general protection of paintings, in so far as it may be secured by treatment of the atmosphere of the premises in which they are kept.

We may conclude from these preliminary considerations that *changes* in the hygrometric reading must be reduced to a minimum; the optimum reading round which the oscillations of the relative humidity can centre can then be established.

28. — We have no adequate information at present to enable us to fix an absolute standard. The reason for choosing 60 to 65% as the figure for relative humidity for practical purposes is that in many climates it is the nearest approach to the conditions in which a degree of stability may be easily obtained. It must be observed, however, that this figure, which is quite suitable especially for oil painting with a wood or canvas support, does not necessarily represent the right surroundings for all the constituent parts of all kinds of paintings. For water-colours, in particular, where the process of deterioration depends on both humidity and light, a still drier atmosphere would be more suitable; but the support —paper, vellum, canvas, etc.—would suffer. Another point should be taken into account, as it also decreases the absolute validity of the standard given above: objects reaching the museum have often had a long habit of environments very different—damper or drier—from those of a normally conditioned exhibition room; if the necessary precautions are not taken to get the object gradually used to the new surroundings (which is sometimes impossible), damage is unavoidable.

Bearing in mind these reservations, we shall examine what methods are available of maintaining the composition of the air within reasonable limits and what

factors can be utilised to obtain a balance between the water content of the objects and of the surrounding air.

In a temperate climate, 60% of relative humidity is the easiest standard to keep up. At normal temperatures, this represents comfortable conditions for the human organism. As to the temperature, visitors in most countries of northern Europe are satisfied with 16° C. and will even accept a lower temperature since coats are usually kept on in art galleries. In America, the usual temperature is 21°. The human organism is not very sensitive to deviations of 30% or even more from the normal temperature. On the other hand, if the atmosphere is near saturation point, the presence of water-vapour becomes more noticeable on account of the comparatively reduced evaporation of the organism; but below 70% of relative humidity, very drastic changes have no effect on the visitor's comfort. It may thus be assumed that atmospheric conditions at present considered normal for the majority of objects in museums will also be acceptable to visitors.

Let us now look at the five principal factors in air-conditioning:

1. Extent of air renewal;
2. Pressure of the atmosphere;
3. Temperature;
4. Water-vapour content;
5. Amount of dust, oxides of sulphur and other impurities.

Extent of air renewal.

29. — No adjustment can be perfect, especially since the conditions required must be, for various reasons, quite different from those of the outside atmosphere. In the case of a new building to be erected, the first step will be to collect all available information on atmospheric conditions throughout the year. In normal brick or stone buildings, variations of temperature and humidity will not be felt so keenly as outside; the lag will be due to the insulating powers of the material, the arrangement of the windows, the type of roof, the direction in which the building faces and the number of times an hour the air is changed. All these factors must be taken into account when studying the ventilation scheme of either an existing building or the plans for a new construction. Generally speaking, the amount of fresh air taken from outside should be reduced to a minimum in normal times; care should be taken, however, to counter the effects of a sudden rush of visitors by providing adjustments to compensate for

the extra humidity thus brought in and the more frequent changes of air required. In buildings where rushes are expected, and where large supplies of fresh air are consequently required, the most reliable method would be to place objects that are particularly sensitive to water-vapour in sealed glass cases insulated from the air of the room and fed with conditioned air.

A frequent error in both the conception of ventilating plants and the administrative regulations of museums is the supplying of far too much fresh air at too frequent intervals. Some plants change the air up to three or four times an hour when one partial change would be quite enough. A similar mistake consists in setting ventilators to work to bring in air from outside without checking the effects of the air change. It can easily be imagined what happens when the ventilators are turned on, for instance, when the weather is hot and damp, on days when it is a great temptation to set them going full swing—the almost saturated hot air is introduced into the building during the hottest hours of the day and may cool down in the evening and during the night, so that the inside atmosphere reaches saturation point. The one legitimate use of ventilators is to make the air circulate, not to draw in air from the outside. In a museum room from 4 m. 50 to 6 metres in height it is unnecessary, for the great majority of the exhibits, to change the air at a higher rate than a half or three quarters of the volume of the room per hour. Should there be an exceptional afflux of visitors, it is the curator's job to decide how far the requirements of conservation should be sacrificed to the visitors' comfort; for only suitable compensation obtained by means of air conditioning can balance out the intake of humidity due to the visitors and the admission of fresh air.

Atmospheric Pressure.

30. — The atmospheric pressure inside a building cannot be effectively regulated except by mechanical ventilation. If a proper plant is available, care should be taken to keep the inside pressure always slightly higher than the outside, to prevent non-conditioned air from entering in accordance with the laws of equilibrium. This principle is incorporated in the 'Plenum' system which is based on the distribution of air already under pressure.

Temperature.

31. — As we have pointed out above, the temperature generally adopted is that demanded by the comfort of the visitor, about 16° C. in north European

museums and 21° in America. This temperature is suitable for the conservation of objects, provided that the other atmospheric conditions required can also be secured. But whenever these conditions can be adjustable, a lower temperature should be adopted, for several organisms (parasites, etc.) become harmful at about 20°. There are few museums where the temperature of the exhibition rooms is constantly regulated throughout the year: the structure and lay-out of the existing buildings would make it impossible, or at least very expensive, to cool down the premises during the heat of summer, especially when the atmosphere is particularly wet; in such cases, the air would first have to be cooled down on entry and afterwards heated up again to reduce its percentage of humidity. The solution most often adopted will be to set apart one or two rooms where a suitable atmosphere meeting the requirements of specially delicate works can be obtained.

This is not the place for a detailed description of heating systems and a comparison of their merits. It will suffice to point out one or two details concerning central heating, which is more and more frequently used. (We would note *en passant* that the system of open fires—stoves, etc.—is fairly satisfactory from the standpoint of air-conditioning; but it has serious drawbacks—ash and coal dust, fire risk, heat too localised).

Generally speaking, with heating by radiators, it is often not realised how difficult it is to keep a uniform temperature in all parts of a room, especially when the premises include outside walls, the temperature of which on winter days is sometimes 3 to 6° lower than that of the premises inside. Consequently, should a painting or a glass case be placed against such a wall, it will be exposed to serious risks of deterioration, as the relative humidity will be quite different at the back and at the front. These conditions cannot be checked by a casual examination; things would have to be pushed to the extreme for the naked eye to be able to ascertain traces of condensed water vapour; but the deterioration of course occurs well before the phenomenon in question can be discovered. There are special thermometers for checking the temperature of the architectural elements of premises—walls, floor, ceiling. They could be used to find out the critical points, and the latter could be borne in mind when placing the objects. A remedy should not on any account be sought in altering the position of the radiators so as to direct their heat on to the critical spots, as this would merely increase the discrepancy we have already mentioned between the back and front of the object.

These reservations must not be taken as a condemnation of radiator heating;

they merely show that great circumspection is needed in the choice and placing of radiators.

The system of radiating panels on the walls or ceilings, heated by water or electricity, provides an agreeable atmosphere and has the advantage of leaving the floor space quite free. The panels should always be as big as possible so as to give a suitable temperature with elements that do not get hotter than 45° C.

The ideal arrangement would be to provide for a cavity in all the outside walls and roofs; this cavity would be scientifically insulated and fed with hot air, so that the inside surface could be kept at a constant temperature of 17° at the maximum. It would be sufficient to add extra heating to bring the incoming air to the same temperature and to feed small heating panels near the windows, so as to make up for the loss due to glass surfaces. This system would be too expensive for an original lay-out, but would be economical in use and should not be rejected without consideration in the planning of lay-out schemes.

In the usual type of gallery with overhead lighting and walls reserved for hanging pictures, heating is provided through grills in the middle of the floor equipped with a ventilating conduit. This system is generally satisfactory, if it includes the usual devices for insulating the walls, so that the temperature of their inner surface is not too low. Moreover, the glass part of the roof should be surrounded by a heating pipe to prevent the cold from descending into the room.

Water-vapour content.

32. — The question of *hygrometric ratio* has already been studied from the standpoint of its physical, chemical or biological effects on hygroscopic matter. We should like to add here that the essential point is to keep the hygrometric reading within as narrow limits as possible. In this connection, the effective action of the apparatus available should be examined as a compensator of natural atmospheric variations or a controller of the quality of the air admitted into the exhibition premises.

There seem to be certain misunderstandings about the action of air-conditioning apparatus. The term is often taken to mean a simple device for washing air, including only a vaporiser or damp contact points. The air treated by this washing device has a degree of dampness proportional to the length of contact and limited by the degree of saturation which varies with the temperature of the water. If the same washing water is sent back into circulation, the air

will cool down to the temperature it registered on entry and the change it undergoes will be away from, and not towards, the ideal degree. Unless it is fitted with an automatic regulator working in conjunction with a hygrostat, such a conditioning apparatus cannot be more than a damp filter and should consequently only be set in motion on days when the degree of absolute humidity outside is lower than that required by the normal conditions of the premises. It goes without saying that when the water-vapour content has reached or exceeded the required level, only dry filtering should be used, except when the air-conditioning apparatus enables the hygrometric ratio to be lowered.

Amount of dust, oxides of sulphur and other impurities.

33. — Dry filtering will not eliminate gaseous impurities, such as the oxides of sulphur, which are the commonest form of impurity and also the most harmful. Complete elimination can be obtained by the use of an alkaline washing liquid, but no apparatus for absorbing or rubbing fulfilling the special requirements of a museum has as yet been perfected. Such a system, which encounters no practical difficulty in the way of handling or supervision in a laboratory or a chemical works, could not be used in a museum where control by a specialist can take place only infrequently and where it is imperative to adopt an equipment that can be worked by the mere turning of a switch or the opening of a valve.

The purification of all the air entering a museum would be a very difficult problem, considering the enormous amount of air to be treated. Once again, we are forced to the conclusion that for particularly delicate objects, local conditioning—in a glass case containing several objects, a small room or a picture frame, etc.—will in most cases be the only practical proposition.

Very satisfactory results would, of course, be obtained if factories and works could be prevailed upon to consume their own sulphur emanations by fitting absorption apparatus in their chimneys.

CHAPTER IV

THE ACTION OF LIGHT ON PAINTINGS

34. — Light, especially in the presence of moisture, is a potent factor in the fading of pigments, the nature of the action being modified considerably by the type of medium in which the pigment is ground.

Experiments have shown that the most active rays are those near the violet end of the visible spectrum. While ultra-violet light is not so chemically active as those rays which are visibly transmitted through blue glass, its effect cannot be ignored. Blue, violet and ultra-violet rays are by far the most active in causing the fading of pigments, the amount of fading depending on the intensity and time of exposure.

Sunlight contains far less blue light than does sky light, and when reduced to equal intensity sunlight is only approximately half as active in causing the fading of fugitive pigments. The heating effect is decidedly deleterious, however, and on this account no picture should be exposed to direct sunlight. Exposure to a blue sky for long periods is likewise to be avoided, by reason of the activity of the blue and violet rays. Under the same conditions of intensity, the fading caused by incandescent light is quite negligible. It should be mentioned that light reflected from a glass mirror contains, at equal intensity, a smaller proportion of ultra-violet rays than that contained in direct light and that it is therefore more suitable for delicate paintings. The pigments which, when fugitive, are most affected, are those most capable of absorbing blue and violet rays, namely, the reds, yellows and greens.

35. — The binding media vary in their reaction to light, some being entirely unaffected (water-colour medium) and others (tempera, poppy-oil) change only to a slight extent. If a painting in which linseed oil has been used is insufficiently illuminated, however, the oil darkens, becoming yellow and eventually brown, and the whole picture is lowered in tone in consequence. Oil paintings should be hung and stored in such a manner that they are exposed to a good white light—a north light where possible. Those which must occupy less

favoured positions should be taken to good lighting periodically if they are to be maintained in good condition. A scheme of storage in which pictures are hung on vertical screens mounted on castors has much to recommend it as the position of the screen can be readily changed and the lighting controlled. For reasons that will be readily understood, however, this scheme is not one that can be generalised in museum buildings; furthermore, there is a risk that paintings will be shaken if all the necessary precautions are not taken to ensure a proper equilibrium of the screen and to eliminate vibration from the castors. The lighting may also be controlled by louvered shutters fitted into the windows. The darkening of linseed oil can be mitigated by exposure to bright light until the oil is bleached to its original colour.

36. — Prints (1), such as mezzotints, which contain much oil require to be exposed to a good light at intervals of a few months. They are usually stored in darkness and, if not attended to, become dull and often mildewed, the oil acting as nutrient material for moulds.

37. — Water-colours soon become lowered in tone by over-exposure to light, as the medium affords little or no protection to the pigments; more rigid precautions in this respect are therefore necessary than is the case for oil and tempera paintings. Such drawings should be stored in darkness, suitably mounted to prevent rubbing, and ought not to be hung permanently in the exhibition gallery. In summer, it may be an advantage to introduce velaria under the roof lights of the water-colour gallery or to coat the outside of the glass with a mixture of whiting and size. Delicate specimens should be placed in dull light or should be protected by some form of screen, such as a movable curtain of woven material. The best materials for curtains are matted fabrics of the velvet type which are quite opaque, but any textile may be employed if it is lined with some kind of light-tight fabric. A simple test is to expose the proposed fabric over sensitised paper in a photographic printing frame and to observe the result on developing the paper; the silver image should be practically non-existent. The colour of the curtain is immaterial and may be chosen to harmonise with the general decoration scheme.

(1) A special study dealing with this type of works of art was published in *Mouseion: La Conservation des Estampes, Dessins et Manuscrits*, by H. J. Plenderleith; Vol. 29-30, pp. 81-104, and Vol. 333-4, pp. 199-226.

38. — The glazing of picture frames diminishes the action of ultra-violet light to some extent; the main arguments in favour of the use of glass are connected with other aspects of the subject (general mechanical protection, hygiene). No special glasses designed to filter the chemically active rays are yet available which are themselves colourless or sufficiently clear to be used for framing or for roof-lighting, and the introduction of such tinted glasses would upset the colour values of paintings.

39. — Special care is required during the taking of photographs, both on the score of lighting and heating. For ordinary photography, the heating effect of a battery of lamps may be lessened by interposing a large sheet of plate glass between the lamps and the picture. This applies more particularly in the case of the long exposures sometimes required for the photographing of oil paintings. Photography by ultra-violet rays should be restricted to subjects which do not require long exposures, as the heating effect of the quartz lamp is generally considerable. A suitable light filter such as a Wood's screen should be employed in practice, and invariably where fugitive pigments are suspected to be present. (This question is dealt with in greater detail in Chapter II).

CHAPTER V

EFFECTS OF CANDLE SMOKE AND CERTAIN METHODS OF HEATING

40. — It sometimes happens that valuable paintings which are or have been kept in churches or other places of worship become seriously damaged by *candle smoke* or even by the actual flame of the votive lamps.

This is not without its alarming side, as the damage caused by smoke or flame may be very great; and the habit of placing candles or lamps near the sacred images, which is very common in several regions, shows no signs of disappearing. The people and sometimes ministers of religion themselves are so strongly attached to their habits and traditions that they cannot easily be persuaded to refrain from a practice that has already done irreparable harm.

The grease given off by candle smoke and incense has a tendency to combine with dust to form a crust on the painted surface, which quickly turns quite black. This crust is sometimes so old and adheres so strongly to the painting that it is a very delicate matter to remove it. Moreover, on account of their very nature and composition, the grease deposits tend to pierce the film of paint and combine with the substance of the picture. Naturally, the phenomenon is more likely to occur when the pictures are not protected by a varnish which is proof against such emanations. Paintings with a very smooth surface protected by very resistant varnish may, however, be cleaned with considerable chance of success. It is advisable, in the first stage of operations, to soften the deposits with highly purified fatty substances; they may then be removed, keeping the paint as dry as possible.

In this connection, we may quote the example of a thirteenth century panel, representing the Crucifixion, exposed for centuries in the church of San Domenico at Naples, to the gaze of worshippers and thus to the fumes of candles and incense. The restoration of this work to its original conditions was made possible mainly by the fact that it had been protected from the outset by a robust and extremely transparent varnish, which was retained on the restored picture.

41. — But the most serious damage is caused by the flames of lamps or candles —swelling or burning of the painted surface. Burnt areas must be regarded as irremediably lost; swellings may often be cured by attaching the affected film to the support by means of an adhesive or by running in melted wax. It is obviously better to take drastic steps to protect valuable works against accidents of this kind while there is still time. A good example is that of the Antiquities and Fine Arts Administration in Italy, which drew the attention of the ecclesiastical authorities and the priests entrusted with the upkeep of churches to the risks incurred by their pictures and the necessity of personally supervising precious works of art exhibited to worshippers on holidays and during processions. The result was that, in almost every case, oil-lamps and candles were replaced by electric light and the most valuable paintings were placed under glass.

Many episcopal authorities have issued orders of this kind, while, on their own account, the Central Committee for Sacred Art and various diocesan committees in Italy drew the attention of those who are responsible for churches to the serious damage that may be caused, especially to paintings and sculptures on wood, by the practices mentioned above.

42. — Attention must also be paid to the *effects of smoke from fireplaces*, above which paintings are frequently hung in private houses and in some reconstructions of interiors. It can easily be observed that, after some time, soot is deposited, especially on the upper part of the picture, as the smoke (some of which always escapes into the room, however well the chimney draws) follows the mantelpiece and then curls round on to the wall. Valuable pictures should therefore not be hung above fireplaces, just as they should not be hung above pipe radiators; apart from the risks of overheating and desiccation, these radiators form a dust-attracting aera, the dust adhering to the wall above the source of heat.

CHAPTER VI

REACTIONS OF THE CONSTITUENT PARTS OF PAINTINGS TO HUMIDITY AND TEMPERATURE CHANGES

We have already given a general account of how hygroscopic matter reacts to changes in the hygrometric ratio of the surrounding air. We shall now give further details of the effect of such changes on the constituent parts of a picture — support, priming, paint-layer and varnish.

It may be observed that a picture, as a whole, is always sensitive to hygrometric variations.

The Supports.

43. — Generally speaking, humidity may be the cause of biological growths in the size of the priming-layer, which penetrate to the back in the case of a canvas and collect round the sides when the support is of wood.

The repeated expansion and contraction of the wood or canvas eventually causes deterioration of the priming layer and the paint film, which in time lose their elasticity and adhesive powers. Besides these movements of shrinking and swelling, the wood undergoes a continuous contraction transversally to its grain. This contraction warps the panel, as the front, which is protected by the priming and the paint, gives up its humidity more slowly than the back and, in consequence, is less inclined to shrink. Hence the convexity of most old paintings on wood.

Canvas too suffers continuous distortion apart from the tensile and compressive movements due to the alternation of dampness and dryness. It is to avoid over-sensitivity to hygrometric fluctuations that canvases are often 'shrunk', i.e. repeatedly wetted and stretched. This operation is of particular importance when the canvas is intended for relining.

It has been observed that, in spite of their apparent fragility, the paper or parchment supports often used in olden times, fastened to a more rigid support, often prove to be the most resistant of all vegetable supports. (See also § 185).

Priming.

44. — A detailed account of the effect of humidity on the priming will be found in the chapter devoted to that subject. We must mention here, however, the special effects of repeated variations in the hygrometric ratio on the component parts of the priming. (All sizes, apart from casein, absorb water. For a time, they follow the movements of the support. When they have lost their elasticity, they give way and develop crackles.)

When the humidity increases, *light primings* (plaster, calcium or ochre, bound in a glue of animal or vegetable origin) absorb the water vapour and become slightly thinner; a return to dry atmospheric conditions evaporates the water absorbed, which takes with it part of the thinned-out size. Thus the priming layer gradually loses its adhesive powers and, in extreme cases, may actually come away from the support. If the picture already shows cracks, it will flake; otherwise, it will blister. Repeated alternation of dryness and dampness may even cause complete evaporation of the size. The absolute humidity and variations in the hygrometric conditions of the atmosphere have thus a decisive effect on the priming and, consequently, on the conservation of the painting. For the adhesive quality of the priming is an essential factor in the conservation of the paint-layer.

Heavy primings have a base of oil and white lead or other pigment. They are none the less open to the influence of humidity as they are always laid on with a light glue, applied in a thick consistency. The object of this is to prevent the paint from oozing through the interstices of the support and to make the paint adhere perfectly to the support.

There are also *mixed primings*— heavy primings applied over light ones— which must be distinguished from the mixed primings proper in use from the XVth to the XVIIth century. These appear to have been emulsions, their characteristic feature being their ability to take both fatty and non-fatty substances. They also seem to have been far more able to withstand weather changes and show very little cracking; the cracks that can be found are probably due to the paint rather than to the supporting layer. The conclusion seems to be that emulsions are less sensitive than oil or glue alone to hygrometric variations.

To sum up, primings have a glue base, and this is highly sensitive to variations in hygrometric conditions: in a dry place, it hardens and causes crackling; in alternations of dampness and dryness, it disintegrates and evaporates; in a

wet environment, water penetrates through the cracks and the glue thins out and loses its adhesive powers, causing flaking.

It should not be forgotten that humidity works its way through the support, from the back to the priming, to an extent that varies with the kind of support and has a similar deleterious effect.

Paint layer.

45. — This is not the place to describe the ways in which the paint layer reacts to variations in the surrounding atmosphere. The constituent parts of the painting, as will be seen in the detailed chapters in Part II, are the deciding factor in the changes that take place in the paint film due to atmospheric variations. On the other hand, only the paint layer is affected by light. For this reason, a special chapter has been devoted to this subject in this general part of the Manual.

Varnishes.

46. — Resin varnishes absorb water. Some resins absorb as much as 20 to 30% of their own weight. If boiled oil and resin be mixed under unfavourable conditions, the resin will be inadequately protected and will absorb water and turn white. This is the first stage in the development of mould.

Details of the disintegration of varnish are given in the chapter on the protective layer, which also contains information on wax varnishes, a more effective protection against humidity. We must mention here, however, the symptoms of deficiencies in the atmospheric conditions to which pictures are exposed.

In the case of a well-mixed varnish, humidity may be deposited on the outer surface, which turns cloudy; it may then disappear when the atmosphere grows drier. Frequent repetition of this process may, however, cause lasting deterioration.

The first sign of trouble is a dark, bluish film, especially visible on the blacks of the picture; the film thickens and whitens and may eventually cause complete disintegration of the resins.

Once again, the only remedy is to keep hygrometric conditions as constant as possible, between 40 and 60%, especially avoiding repeated deviations from the degree chosen. (See also §§ 121-130.)

CHAPTER VII

HEATING AND AIR-CONDITIONING

A study of the points dealt with in the previous chapter may provide certain standards for the curator in his choice of precautions to secure the right atmosphere for the objects in his care. They will also help him to give the right information and instructions to the architects and fitters whose job it is to construct, alter or equip the premises of his art gallery.

The expense involved in adequate air-conditioning seems at first sight hardly off-set by the saving in restoration costs such a process implies. It will therefore be nearly always necessary to make the best of the means available by using them as carefully as possible.

Heating.

47. — As every specialist who has studied the question acknowledges that hygrometric discrepancies have a more harmful effect on paintings than the degree of moisture content of the air, curators should devote most of their efforts to this point. Too violent sources of radiant heat near the pictures are to be avoided, on account of their local drying effect and of draughts, the intensity of which is in direct ratio to the proximity of the heating supply.

If heating is effected by means of *stoves*, they should be placed outside the rooms. If this is done, the exhibits will not be exposed to direct heat waves or to coal-dust, smoke or sulphur fumes.

48. — When heating is obtained by means of *hot air*, it is essential to equip the heating inlets with filters to keep back the dust and to regulate, to some extent, the humidity of the atmosphere. Care should be taken in the ordinary way to study the circulation of the hot air so as to avoid placing objects in the path of the main currents, which, besides being harmful in themselves, always imply a certain amount of dust suspension.

49. — Heating by means of *radiators* always dries up the atmosphere. The hot water system is in any case better than steam, for the apparatus is more solid and works at a lower temperature than the smaller and hotter steam apparatus. Moreover, hot water radiators take much longer to get cool than steam radiators and thus avoid too sudden drops of temperature, should it be necessary to cut off the heating during the night—an inadvisable process for an art gallery.

50. — It is always better to use large heating apparatus at a temperature not higher than 45° C. to avoid excessive drying of the air and strong local eddies. The use of *saturators* or other evaporating devices can never fully make up for the drying effects of radiators. No central heating system should be fitted without the indispensable corollary of a *compensating system for moistening the air*. The necessary details concerning the placing of the heating apparatus have been given above.

51. — Whatever kind of apparatus is in use, *too sudden changes of temperature must be avoided*, not only during transitional periods such as spring and autumn but also during the months when heating isr equired. In winter, the temperature must be kept constant at night as well as in the daytime. The reasons for this have been given above, in the chapter dealing with the relations between temperature changes and variations of the hygrometric reading.

Ventilation.

52. — Under these conditions, ventilation should receive equal, if not greater, attention. All ventilation systems that bring about too sudden changes in the hygrometric ratio must be avoided. In particular, *window ventilation*—which means letting in air of a temperature and hygrometric condition appreciably different from those of the air in the room—*is to be eschewed whenever the air can be renewed in other ways*, e.g. doors, air-inlets, etc. Draughts, we would repeat, are extremely dangerous.

Draughts.

53. — At all times of the year and at all hours of the day, care should be taken to detect draughts, whether caused by the heating system, as we have already pointed out, or due to any other reason whatsoever. There should be constant

supervision as well as attention to particular cases. A piece of cord or ribbon held at one end against the wall wherever a picture is hung is a valuable help in detecting draughts. By this means, danger spots can be located and remedies sought. Pending a new lay-out to eliminate draughts and should no remedy be found, the best thing to do is to take especially sensitive objects away from the danger spots. We might add that air currents are appreciably reduced by means of curtains across the entries to the room.

To keep atmospheric conditions as constant as possible, insulating substances (cork, celotex, etc.) are available for the walls. These may often be used in an existing building. In connection with the circulation of visitors, certain changes might be made in order to condemn entry doors, which in any case are best reduced to a minimum.

Regularisation of hygrometric conditions.

54. — One of the improvemente that can be made in existing buildings is a process for obtaining an appreciable degree of regularisation of the hygrometric conditions of exhibition rooms. Many museums have a stock of pictures, textiles or other objects which for some reason or other find no place in the exhibition rooms. These objects, often packed in chests, cupboards or other articles of furniture stowed away in cellars or attics, are a very valuable asset that can be called upon for conditioning the air of the exhibition rooms. It should be possible to store all these objects in warehouses in which the air of the exhibition galleries, as soon as the humidity reaches the stipulated level, could be made to circulate. The ventilators used to stimulate the circulation of the air ought not to be set in action (automatically, by hygrostats) until the atmospheric conditions of the gallery necessitate the action of the drying or moistening powers of the hygroscopic matter. With this system, it must be realised that the reserve stocks will also enjoy improved conditions, on account of the reciprocal action taking place between them and the objects in the gallery.

55. — This method, in conjunction with a vaporiser, has been adopted in the Hampton Court Orangery, London, where the Mantegna cartons are on view. Like most orangeries, this building has a glass wall to the south, far too big to allow pictures to be hung. Before the air-conditioning apparatus was fitted, the degree of relative humidity varied between 30 and 90%. At present, during nine months of the year, these variations can be kept within 10%; in July.

August and September, the absolute humidity outside is too high for the canvases to react adequately. But even during those months the regulator ought to make it possible to keep hygrometric variations down to 20%.

The most frequent air-conditioning problems are thus connected with existing buildings which do not permit of a full, rational equipment. It has already been pointed out that the cost of such an equipment with the appropriate insulation in the case of a new building is unavoidably so high as to make a compromise the most usual solution. To obtain ideal conditions, with not more than one or two degrees of heat variation and four degrees of humidity variation throughout the year, the first step would be to insulate the building by means of cork or some such substance, equip all the entries with air-traps, in fact, treat the building as though it were nothing more or less than a refrigerator. There are few examples of museums built in this way.

Perhaps one of the nearest approaches to perfection is the new annex of the British Museum Library, built of insulating substances (cork, etc.) and fitted with air-conditioning apparatus, including refrigerators.

The only cases we can deal with here are examples of partial conditioning that will serve as illustrations of our theoretical remarks.

The new Museum of Art at Portland (Oregon) is fitted with a complete system of ventilation which forces the air through filters and works entirely automatically. There is no refrigeration, but the town water, the temperature of which is 14°C., can be used for the dispersion apparatus in very hot weather. Throughout the year, the relative humidity inside the building is said not to vary more than 15%.

A decrease of relative humidity, due to the heating, is the system adopted in a small room of the National Museum at Copenhagen; the hygrometric reading varies between 45% and 65%. The necessary heating is obtained by means of a small electric radiator controlled by a hygrostat which turns the current on when the humidity reaches 65% or so.

In some of the Berlin museums in hot, damp weather, cool air is taken from the cellars where the temperature is low. This system, however, would presumably be less efficient in long periods of damp heat.

CHAPTER VIII

LOCAL PROTECTIVE AND PRECAUTIONARY MEASURES

56. — Various systems of keeping pictures protected from atmospheric variations have been advocated. In the chapter on general environmental conditions —conditions which are often unattainable in the premises as a whole—we mentioned the possibility of local protection by air-conditioned show-cases. Means of protecting each individual picture have also been studied—covering the surface or the back, or placing the picture in an air-tight frame.

Some restorers have thought it possible to preserve pictures by coating the back with a water-tight substance with an oil, wax, or paraffin base. The panel would be insulated at the front by its own varnish and at the back by this layer, and would thus be protected from the surrounding humidity. But as it is impossible—the experiment would be risky—to dry a picture completely, the internal humidity will try to escape as soon as the temperature rises. If the protective layers are elastic, swellings will occur; if they are not, crackle will develop, especially in the front varnish. There will also be fermentation inside the confined space.

Sticking paper on the back is not an advisable remedy, for it warps the panel and produces a network of cracks that let in humidity. The use of tow is no better a cure.

These observations justify our conclusion that nothing should be done which might hamper the normal ventilation of the picture.

We must nevertheless mention the experiments made in recent years in Canadian galleries where pictures have been placed in sealed frames. In the Victoria and Albert Museum, forty years ago, a Turner was submitted to the same treatment, and has since showed no signs of deterioration. Covering the back of the picture with tin-foil has also been recommended; but in that case, all the humidity in the support, priming and paint-layer must escape through the front.

Protective Glazing.

57. — Glass prevents the picture from being properly seen, on account of reflections. This disadvantage can be reduced by slightly inclining the picture if the bottom part of the walls and the floor are mat and dark in colour.

In towns where the atmosphere is heavily charged with dust and harmful gases, valuable pictures should be protected by glass. Pictures on wood, which are especially sensitive, particularly when showing signs of decay, would also be more effectively protected against sudden changes of temperature if placed in glass-covered containers.

By a suitable device fixed to the edges of the picture, the paint must be kept away from the glass. The front of wood panels may be found to be within a centimetre of the protecting glass due to the "movement" of the wood. Contact of any kind may cause the varnish and even the paint-layer to deteriorate. (During transport, the glass must, of course, be removed in order to avoid risks of breakage.)

The glass must be of good quality and smooth surface. Some glass may show crystallisation phenomena or retain humidity. This will be noticed only after a time and faulty glass should be replaced. Consequently, all protective glass must be kept under constant and scrupulous attention.

It might be advisable to arrange for the glass support to open and shut like a window, so that whenever necessary the picture may be examined more closely.

For pictures that are more particularly exposed to contact with visitors, glass is obviously an effective protection.

Generally speaking, air-tight sealing is to be avoided.

Several attempts have been made to get rid of the disadvantages of glass by applying a very thick layer of varnish to act as a protective coat. The method has, however, the following drawbacks: *a*) the varnish gradually turns yellow; *b*) deterioration of the paint layer may occur, due to evaporation of the essential oils; *c*) the thickness of the protective layer is often more of a nuisance than glass, as it blurs the brush-work and texture of the painting.

Framing.

58. — It goes without saying that we shall deal with this question purely from the standpoint of the picture and its conservation, without entering into details of the æsthetic effect of the various kinds of frame. Whatever kind is

used, the first requisite is that the rebate should be so designed that the "movement" of the wood—of the frame or of the picture (wooden panel or canvas stretcher)—cannot cause accidents round the edges of the painting and does not hamper the contraction and expansion of the painted panel. The rebate should always be about one centimetre larger than the picture; if there is no play, paintings on wood may get wedged and become distorted, and canvases cannot be restretched. It is a good plan to put pieces of cork or rubber between the edge of the picture and the rebate. The state of conservation of the frame should be carefully examined, especially from the standpoint of parasites which can easily use the frame as a starting point for an attack on the picture. Should it be necessary to treat the wood of the frame with insecticides or impregnating substances, the picture must be removed from the vicinity, as the fumes may cause deterioration of the colours.

Fixing of pictures in frames.

59. — Any method of fixing that involves shaking the picture must be avoided, as when the picture is put into the frame or taken out of it fragments of paint may quite possibly become detached.

Instead of nails, steel springs should be used, with screws (1). This method also has the advantage of allowing the wooden panels some freedom of movement, as they have a tendency to warp, and often crack if held too tightly in the frame. In transport, however, when the picture is left in its frame, the latter must be kept immobile, so as to avoid shaking the picture.

Neither nails nor screws must ever be driven into the wood of the panel or the canvas support or the cradling.

The system of extensible frames fitted with keys driven in with a hammer is not recommended unless the keys can be suitably adjusted to avoid hampering the free play of the panel.

Protection of the back of the picture by sticking paper on the frame is to be avoided. Better protection against dust and sudden temperature changes is afforded by porous fabric for wood paintings or a sheet of plywood.

To ensure canvas paintings against shocks or other accidents, sheets of cork or plywood may in some cases be applied to the back, as near as possible to the canvas, but not touching; a tight fit is to be avoided.

(1) The steel springs should always be removed when the picture is packed for transport.

Air-tight sealing must in all cases be avoided, on account of the danger of biological growths.

Nothing should ever be stuck direct on the back of the canvas, as additions of this kind easily show through and stand out in relief on the front surface.

Hanging.

60. — Pictures should never be fastened flat against the walls; there should always be free circulation of air behind the support.

In accordance with the detailed instructions in the paragraph on the heating and hygiene of exhibition rooms, great care should be taken to examine the condition of the wall on which the picture is to be hung, especially from the standpoint of humidity. It should not be exposed to draughts or the direct rays of a heating element.

Good ventilation conditions can easily be obtained by slightly tilting the picture forwards; this also keeps it freer from dust.

In general, pictures should be hung in such a way as to be easily taken down in case of fire. How can this condition, in the case of small pictures, be reconciled with the necessity of *protecting them against theft*? They might be hung in groups of two or three on a common rod fastened to their frames. If this is done, a single picture cannot be taken away without removing a whole set, which would doubtless attract the attention of the attendants.

61. — Whatever system of hanging is adopted—horizontal rod fixed on a level with the cornice of the room with hanging vertical bars fitted with the Boyer system; metal rail to receive either the picture hook or the suspension bar; direct fixing to the wall by means of hooks, etc.—special precautions must be taken if the gallery is near a busy thoroughfare. The vibration caused by the passage of heavy vehicles can cause serious damage to pictures. This vibration can be absorbed by small cork or rubber pads, inserted in the hanging system at the various contact points, and similar pads may be placed between the wall and the bottom of the frame.

General cleaning of the premises.

62. — During cleaning, care should be taken to raise as little dust as possible and draughts should be avoided. It is recommended to use vacuum cleaners and damp sawdust for sweeping up.

Watch should be kept, however, for air eddies and drying of the atmosphere due to the use of vacuum cleaners, especially the movable type; these disadvantages can be greatly reduced by the installation of a system of fixed suction points in various parts of the room or preferably in the corridors.

Dusting the picture surface (*see also Chapters XI and XII*).

63. — Paintings should be dusted only in exceptional circumstances, under the supervision of the restorer. For even the use of very soft brushes or cotton-wool, which is the best substance to use for this purpose, may damage the varnish. Particles of paint, even, may often be brushed off; and usually only the specialist will notice this. Dusting must definitely be regarded as an extremely delicate business and must not be entrusted to an inexperienced staff.

A preparation tha tcan often be recommended, but which only the restorer should apply, is a mixture of highly rectified paraffin oil and a little beeswax or paraffin wax; a plug of cotton-wool wrapped in wash-leather is dipped in the liquid and wiped over the picture, which is thus slightly moistened. The surface is then polished dry, gently and without pressure. This process eliminates superficial dirt as well as "bloom" (on this point and on "regeneration" see additional details in the chapter on the maladies and treatment of the varnish layer).

It is perhaps not superfluous to issue a warning against a method of cleaning pictures still in use in recent years in many galleries—washing the painted surface with soap and water. The evil effects of this system are not immediately apparent; but the water may penetrate by capillary attraction through the slightest cracks or fissures in the paint film as far as the priming, which means that sooner or later the film will become detached or swollen, not to mention the bad effects on the varnish.

Conservation in store-rooms.

64. — Pictures which are not being exhibited should be stored in accordance with the same principles, especially since the majority of galleries have nowadays adopted a system of hanging pictures with spaces between them, which means that a fairly large stock of valuable works must be kept in store-rooms. As they will have to be consulted from time to time, these works must be stored in such

a way as to be easily available for that purpose. For these two reasons—conservation and facility of consultation—the organisation of store-rooms needs careful study.

If the pictures are stacked against the walls, serious damage will be caused by friction and the lack of air and light. In the chapter dealing with the paint layer, we shall study the change in colour of oil-paintings kept in the dark. Painted canvases should never be left without their frames and on no account should they be rolled up. The latter method of storage is a great temptation, as a great many canvases can be stored in a limited space; but this advantage cannot make up for the very serious and often irreparable risks of damage incurred by canvases rolled round wooden cylinders placed on supports; the priming, which thus forms the outside layer, sags and splits, the paint layer cracks when the canvas is straightened out, and the lack of ventilation favours the formation of mould, which attacks the constituent parts.

These old-fashioned methods of conservation make it impossible to consult the documents freely, and aggravate deterioration; they also prevent systematic supervision of the pictures that are stacked together. If deterioration is nipped in the bud, it may usually be cured without great risk and at comparatively low cost, and for this reason it is always better to adopt a storage system which allows the pictures to be frequently and easily inspected. Many modern museums have equipped their store-rooms with parallel vertical metal frames fitted with a grill, on which a number of pictures may be hung. The grills are fairly near each other and are fitted with castors that slide along rails in the floor and at the top with pulleys that move along an iron bar across the ceiling. Each grill can be slid out for inspection of the pictures. So that every canvas may be properly lit, the grills must be perpendicular to the window.

In connection with the hygiene of the store-rooms, the same rules should be observed as for the exhibition rooms, as regards cleaning, heating and ventilation.

CHAPTER IX

PROTECTION AGAINST FIRE

65. — Although fires of all kinds are relatively common, they always break out unexpectedly or at least take unawares those whose duty it is to watch over the safety of a building. So the first precaution against fire consists in never losing sight of its possibility.

As regards museums, damage done to a work or art by fire cannot really be compensated even by the most generous insurance. And as most of the objects in museums are valued extremely high, it is natural for insurance companies to cover themselves by demanding very heavy premiums. For this reason, when drawing up its budget, the museum should always bear in mind that the genuinely effective measures of protection against fire, are not so much insurance on a liquid capital as material guarantees of the safety of the objects themselves, which, if destroyed, can never be replaced.

To meet the requirements of an effective organisation for the prevention of fire, the following rules must first be observed in connection with the *structure and equipment of the building*.

Situation.

66. — Buildings containing works of great value must be well separated from any structure from which a fire might spread to them.

Building Materials.

67. — Inflammable materials must not be used, except when absolutely indispensable. In any case, fireproof preparations should be used to make the wood, textiles, etc., non-inflammable and consequently to protect walls, doors, frames; attention should be given to the possibility of applying a fireproofing substance to the backs of pictures, avoiding direct contact.

Painting.

68. — Preparations used in the decoration of doors, windows, exhibition furniture, etc. must contain no nitro-cellulose or other inflammable solutions.

Decorations.

69. — Curtains, blinds and other decorations are to be avoided when there are no imperative reasons for their presence; in any case, they must be fireproofed, as they easily catch fire and are therefore dangerous centres.

Fire sections.

70. — By means of fireproof walls, partitions or doors, the building should be divided into a number of sections; should fire break out in one of these, means will be available to localise it and prevent it from spreading to the other sections.

Air ducts.

71. — Should there be one section of the building that might become a kind of active chimney in case of fire, special care must be taken to avoid the slightest communication between that section and the others.

Danger spots.

72. — It should not be forgotten that every building contains a number of danger spots where fire would rage with particular violence. Typical danger spots are the store-rooms which contain packing cases and other accessories connected with transport or the equipment of the gallery and the restoration studios. These rooms should be completely isolated from the others, so as to avoid all risk of the fire spreading to the rest of the building.

In an old building used as a museum, there is the most serious danger of fire in the attics, where dust accumulates and where repair rooms are often found. It is highly advisable to install these workshops, not in the upper part of the building but in the basements, or better still, outside the museum building.

Boiler rooms.

73. — The boiler rooms also must be carefully insulated. The hot-water system is much better than the hot air system in this respect, as the latter may reach temperatures that would set fire to particularly inflammable substances in the path of the hot air. A principle that cannot always be applied but which provides excellent protection, consists in planning the boiler rooms in a special building separated from the gallery.

Housing of the staff.

74. — Premises housing the museum staff should be so situated as to prevent any fire which might break out in them from spreading to the other offices. There should be a regulation providing for the periodical inspection of these quarters.

Fire due to optical causes.

75. — Fire may sometimes be started by a magnifying glass left on a work-table, or by the concentration of rays of sunlight due to a glass jug or even the window-panes.

Films.

76. — Special precautions should be taken in connection with photographic films (e.g. X-ray films, which, moreover, it would be advisable to keep in the form of paper prints). It should be forbidden to keep films in the work-rooms, if no special precautions have been taken for their storage.

Inflammable liquids.

77. — Motor-cars have become so popular that there is always the possibility of finding some day that supplies of petrol or oil have been stored near the gallery or even in one of its out-buildings. The most scrupulous care must be taken to prevent such a practice.

Electrical plant.

78. — Electric lighting and motive power, which are so reliable and harmless when fitted with every guarantee as regards insulation and supervision, may

EMERGENCY FIRE EXTINGUISHERS

List of emergency extinguishers.	Special use.	Advantages	Disadvantages
A. — **Liquid extinguishers.**			
1. Water buckets.	Indispensable in all cases.		Harmful for paintings on wood and on canvas unless the latter are protected by a coating of wax.
2. Carbonate of soda extinguishers.	For rapid extinction.	Undoubtedly the most effective extinguishers in the majority of cases.	Leaves an acid or alkaline film on the painting. —
3. Water and gas under pressure (CO_2).	Local jets on delicate objects.	Non-corrosive.	
4. Small manuals.			Should, on the whole, be regarded as harmful.
B. — **Dry extinguishers.**			
1. Blankets to smother a fire. 2. Sand buckets. 3. Powders in special containers thrown by hand. 4. Powders projected automatically.	All cases of fire.	Specially suitable for electrical plant.	
C. — **Extinguishers containing highly volatile liquids.**			
1. Carbon-tetrachloride.	Workshops, laboratories and electrical plant.	Suitable for local outbreaks of fire.	$COCl_2$, a toxic gas, is formed by heat. Softens the paint layer, etc. and exposes it to damage by smoke.
2. Mixtures containing methyl-bromide.			HBr, a corrosive and asphyxiating gas, may be formed by heat.
3. Carbonic acid. (These substances can be thrown from a hand container, by a small pump or automatically.			
D. — **Foam extinguishers.** Bottles containing CO_2 with a colloid, producing a neutral foam, would be an appreciable progress as compared with the bicarbonate (acid) type of extinguisher.	Burning petrol.		

Installation : Exhibition galleries. — A1 and B2 should be available at all times. use in picture galleries. — **Workshops :** A1, B2 and perhaps also A2 and B1, or some

Of the extinguishers on the market, preference should always be given to type A3 for extinguisher of the type D. A small container of the type C1 can prove very useful.

cause the most serious fires in the absence of such guarantees. To avoid this danger, the following rules should be observed:

Electric wiring must never be laid on *wood or other inflammable substances.* If there is no way of avoiding this, the wires must be insulated with a substance that is both an electric insulator and fireproof.

Wires must never pass near curtains, hangings or other decorations.

The greatest precaution must be exercised when fitting wires in *damp places.* The humidity, besides setting up conductive areas in materials that are poor conductors when dry, may cause oxidation of the leads and thus decrease their working cross-section; their resistance will be increased and over-heating will take place.

Special attention must be paid to *fuses.* There is sometimes a temptation, when a fuse has blown several times in succession, to replace it with a heavy duty fuse. This is extremely dangerous. Only scrupulously calibrated fuses should be employed, so that other kinds can only with difficulty be used in their stead.

Lightning conductors.

79. — Although cases of fire caused by lightning are comparatively rare, it would be a mistake to neglect methods of avoiding this risk. Lightning is dangerous even for buildings equipped with conductors; it is even more dangerous when the equipment is faulty. The following fundamental rules should therefore be observed when fitting lightning conductors:

Top elements. — A conductor (generally horizontal) with a thick cross-section, should be placed in the main axis of the roof; vertical or oblique bars should run from the chief conductor to the highest parts of the building—turrets, gables, angles or cornices, anything which projects beyond the general line of the building.

The down leads should be composed of a series of vertical bars connecting the upper conductor with the ground; their number will be in proportion to the size of the building, and they should preferably be placed at the angles or cornices that jut out from the general structure.

Multiplicity of verticals is one of the main guarantees of the efficiency of lightning conductors. To avoid the danger of lateral discharge, the down leads should be as numerous and as nearly vertical as possible, without bends or twists or any sudden change of direction that might increase their inductance.

Metallic masses, such as steel girders, water-pipes or other pipes of any kind must be connected to the conductors so as to provide a closed circuit in case of lateral discharge; this is always less dangerous than a simple one-way connection of the metallic mass to the conductor.

Earth. — The earth resistance should be as small as possible; in other words, the area of the surface making contact with the ground should be as large as possible. The best way of achieving this is to connect together all the down leads into the town water mains. When this is impossible, it is inadvisable to use a metal sheet buried in more or less damp earth; the best method is to dig a shallow trench all round the building to contain an iron bar to which all the down leads can be connected; the earth will be all the more effective if this bar is connected to bundles of iron wire, sheet iron or other elements likely to increase the surface in contact with the ground and consequently the conductance of the system.

Supervision.

80. — Considerable risks may arise when *plumbers*, *slaters* or other workmen are working on the roofs or inside the building. On such occasions, the closest supervision by an official of the museum is a necessity. Smoking must be strictly prohibited. A bucket of water must always be kept in the immediate vicinity of the place where work with a blow-pipe is being carried on. Rags soaked in oil and bottles containing inflammable liquids must always be placed even temporarily in a metal box with a lid.

Copyists working in galleries also bring inflammable material with them— petrol, oil, varnish, rags impregnated with volatile substances, and so on. The supervisor of the department must therefore exercise a close watch on the premises during such work and must see that no inflammable material remains in the room after the copyists have left.

The only way of avoiding these risks is by means of perfectly organised supervision, which must be constant during visiting hours and should take the form of repeated rounds when the museum is closed to the public. Such inspection should be particularly strict immediately after the closing of the gallery, for then anything kindled by a cigar or any other means is easily detected. The use of clocks for timing the rounds will ensure the regularity of this form of supervision.

Methods of combating fire.

81. — Various types of fire-alarm—smoke detectors or apparatus reacting to abnormal increases of temperature—have been suggested. However good they may be, it should never be forgotten that nothing can take the place of properly organised personal supervision.

As soon as fire has broken out, the local fire-station must be informed immediately. Its telephone number should be found on all the telephone points connected to the exchange.

In the meantime, hand appliances should be used—extinguishers placed at various points in the rooms, corridors and staircases; fireproof cloth can be extremely useful for protecting both objects and persons likely to be in danger. The sooner action is taken the better; promptness depends on the previous organisation, down to the smallest detail, of collective fire-drill which must be practised from time to time by the entire staff of the gallery. The extinguishers must also be periodically examined by specialists from the firms which manufacture them.

Water, which is an excellent extinguisher when under sufficient pressure, may do as much damage as fire to the objects in the museum. The table given in this chapter shows what extinguishing substances can be recommended or are to be avoided and in what circumstances they may be used.

Closed rooms and safe storage of objects of value.

82. — The most valuable collections, especially those which are most likely to suffer from the effects of fire, should be housed in rooms that may be completely closed after visiting hours. Air is an active agent in the spreading of fire; the doors and windows of these rooms, therefore, when shut, should be completely air-tight. In order to inspect the rooms without the necessity of entering them, the doors should be fitted with thick glass panes, through which all points of the room are visible. All exits must be kept closed, even when fire has broken out. Enough carbon-dioxide should be introduced through a suitable aperture, to keep the oxygen in the air (which mixes with the carbon-dioxide) down to a level below the combustion level (12%). The fire will thus be extinguished without interfering with any object in the room. Of course, care must be taken that nobody is shut up in the room.

In spite of every precaution and everything that may be done, it sometimes happens that the fire becomes so fierce that the only thing to do is to salvage

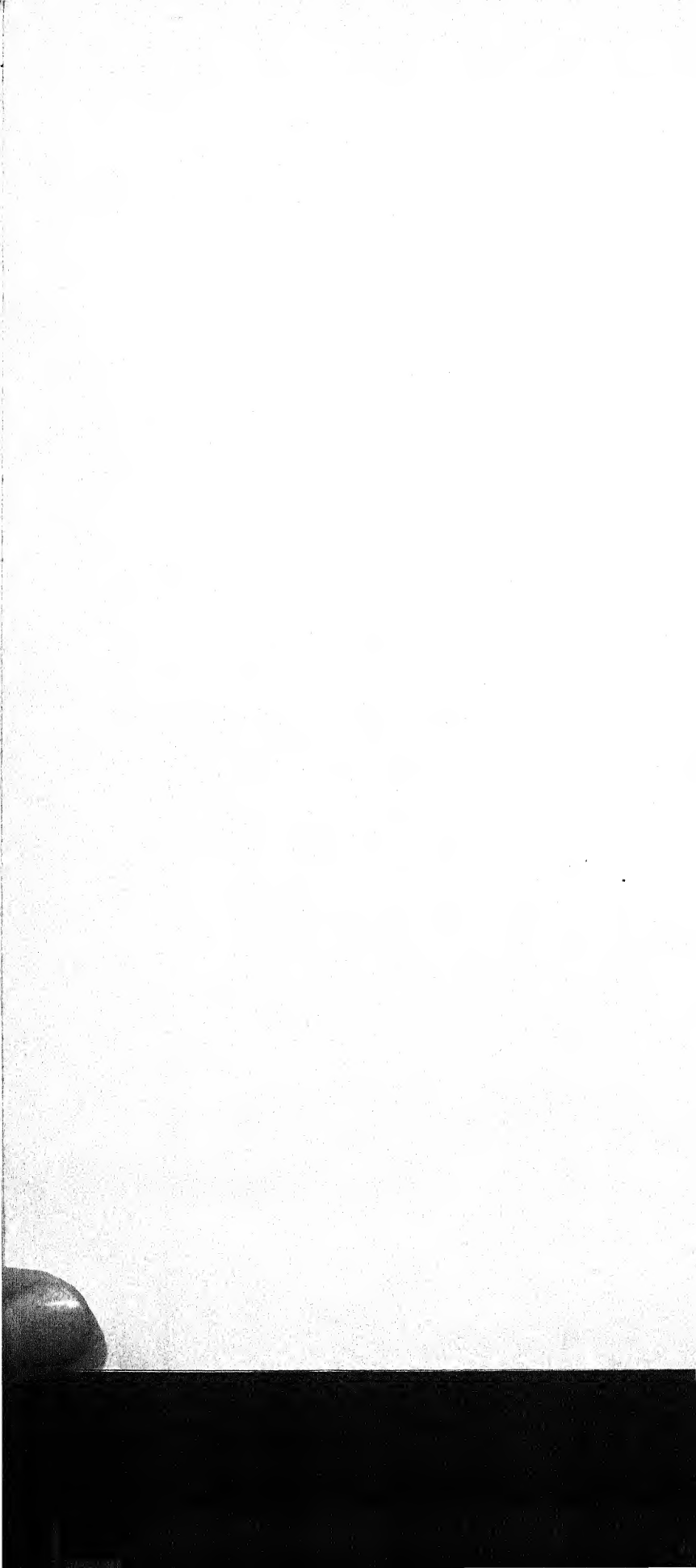
as many objects as possible. In anticipation of such cases, the most valuable objects should be so placed as to be easily removed if necessary.

Risks of bombardment.

83. — The last remark is particularly important in connection with *risks of aerial bombardment* or similar incidents which accompany civil disorder or armed conflicts. The provision of shelters in basements, the drawing up of a list of the most valuable works to be taken down when the air-raid warning is given, with precise details of how they are to be removed, should form part of the protective programme of all museums.

The same observation holds good in connection with the isolation of the building from public services and from any structure that might be regarded as a military objective in war time.

The review *Mouseion* has undertaken to publish a series of systematic and informatory studies on the material protection of works of art in time of war. There is also a considerable amount of graphic and photographic material already available on the same subject. We regard it as essential to draw special attention to this particular problem, even though it cannot be dealt with in detail in this Manual which is devoted rather to the protection of paintings against natural causes of deterioration.



CHAPTER X

TRANSPORT AND PACKING OF PAINTINGS

The remarks made in the chapter on "Surroundings" may be recalled here. Every picture on wood or canvas is exposed to two main classes of risks during transport from one place to another (and even from one room to another)—hygrometric and climatic changes, on the one hand, and shocks, jolts and vibrations due to travelling, on the other.

Precautions before packing.

84. — Without embarking on a discussion of the advisability of transport, e.g. in the case of international exhibitions, we must remind curators of the dangers incurred by any work of art temporarily removed from its customary habitat. The first precaution to be taken is a scrupulous examination of the picture's powers of resistance to the external agents and phenomena to which it will be subjected: condition of the various constituent elements—support, priming, paint layer and varnish. If necessary, any part that might be detached during the journey (flaking, for instance) should be fixed and consolidated. A painting which is still fresh or a recently re-varnished, relined or transferred picture cannot be transported in an air-tight packing without serious risks. The hygienic conditions of the destination should also be examined.

Packing technique and materials.

85. — When the principle of transport has been agreed upon, the assistance of specialists will be sought, so as to have every guarantee as regards the technique and the materials used. The premises where the pictures are packed should also fulfil the required hygienic conditions, so that the air-tight cases in which the pictures are to be kept for a considerable time will contain an

atmosphere whose hygrometric conditions are suitable for the proper conservation of the canvases.

In general, for sea transport or for a long journey, paintings on wood or canvas should be hermetically sealed in cases lined with tin plate, zinc or copper and preferably rubber soldered. The first packing is best carried out dry, with no other material than pads fixing the canvas or the panel in their cases so as to avoid all vibration; for this purpose, the pictures should be wrapped in vellum and then in waterproof canvas. In this way, several small pictures can conveniently be packed into one case. This case is then placed in a second case of thicker wood and of much larger dimensions, in such a way that there is enough space for it to rest on a soft, elastic substance on every side. If several works are to be transported, it is advisable to group the double cases together in larger containers, hermetically sealed, i.e. lined with metal plates soldered together and closed by a lid similarly lined and soldered to the body of the container. The cases inside are separated from each other and from the outside walls by a soft, resilient packing. Zinc—admittedly more expensive than tin plate—is the best material to use in packing.

Prevention of vibration.

86. — In order to avoid the communication of vibration to the canvas, it has been suggested that a kind of sheath might be used, fitting exactly across the framework of the canvas at the back and at the front exerting slight pressure through a pad separated from the painted surface by a sheet of vellum; this system applies equal pressure to both surfaces of the canvas.

Frames and glass.

87. — It is always advisable to pack the frames separately when there is no danger involved in taking the pictures out of their frames. Pictures under glass should also be unframed and the glass packed separately, with the usual precautions: thick paper stuck over the whole surface of the glass and elastic packing in a strong case.

Hermetically sealed packings.

88. — Hermetic sealing of the outer cases is especially important in sea transport. The place where the containers are to be kept during the crossing must

be examined, so as to avoid the proximity of machinery, on account of the danger to the sealed-up paint that would be caused by too high a temperature.

Special attention must be paid to the quality of the packing materials, which should be perfectly dry, especially for hermetic sealing.

Unpacking.

89. — Unpacking is a crucial operation. If the staff who packed the pictures is not available for the unpacking, the lending museum should send along with the pictures a detailed account of how they were packed, to avoid blunders in handling them. We have already pointed out that the hygienic conditions of the rooms in which the pictures are to remain for some time must be previously ascertained; but it is also important to make sure that the place of unpacking shows atmospheric conditions as similar as possible to those of the spot where the pictures were packed.

Transport and acclimatisation.

90. — The foregoing precautions, which apply more specially to transport from one museum to another, are applicable also to works of art taken away from their original home to be permanently hung in a museum. It has been observed that works which have travelled a lot are less sensitive to changes in the surroundings than those which have remained for a long time in the same place. This latter category includes those pictures which have been for centuries in the home intended for them by the artist—castle, church, etc. Special precautions should consequently be taken to get such works gradually accustomed to the atmosphere of the museum room and during the acclimatisation period they should be kept under constant supervision.

An account of the general principles and a mass of technical information on the transport and packing of works of art will be found in the studies mentioned in the appended Bibliography. But we should like to point out here that whenever a picture is removed, even temporarily, it is liable to deterioration. Should it be necessary, for purposes of inspection, photography or for any other reason, to remove a picture from the wall and take it out of its frame, special precautions should immediately be taken for the whole period of such operations. For instance, a sheet of wood fibre should be applied to the back of the panel and stuck down at the corners with adhesive tape. In short, every

endeavour should be made to maintain the conditions of the usual surroundings as far as possible. (Cf. § 84).

Special measures to be taken in war time.

91. — In the same series of articles will also be found accounts of the precautions to be taken and the packing systems to be adopted when works of art are threatened with bombardment. As regards the problems that concern us here, a number of principles will be found in the articles based on recent experiments dealing with: the preliminary choice of works for evacuation, plans for salvaging pictures from the inside of the gallery, methods of packing to avoid vibration, the provision of refuges, and so on. (See also § 83.)

PART TWO

RESTORATION

CHAPTER XI

GENERAL PRINCIPLES CONCERNING THE RESTORATION OF PAINTINGS

Conservation and Restoration.

92. — As will have been seen from the chapters contained in the first part of this manual, no rigid distinction can be made between conservation and restoration where a work of art is concerned. Conservation involves various kinds of treatment which may even result in certain changes or prevent certain forms of decay in the object, but none of these treatments can be said to constitute restoration work properly so called. Similarly, restoration—as we understand it with regard to a painting—may consist in applying a treatment which in no way changes the appearance of a picture but which goes far beyond the scope of mere upkeep and, consequently, the competence of the uninitiated. When classifying the various problems to be discussed, the authors of this manual thought it more rational to devote the first part to everything appertaining to the *doctrine* of conservation, to the hygiene of paintings housed in museums, and to the equipment, processes and conditions of examination which make it possible to formulate a pertinent diagnosis as to the condition of these works of art. The second part, on the other hand, will consist of a description of the *operations* which incontestably require the services of a specialist, a technican, because they directly concern the physical structure of the work. Needless to say, doctrine, which is more or less theoretical, and practical methods cannot be separated, whatever the operation may be, since it is invariably a question of objects to be preserved not only for the sake of historical and scientific documentation but also as testimonies of style and artistic conception.

General Rules.

93. — It must be pointed out and emphasised that, where the restoration of paintings is concerned, very few hard and fast rules exist and that most of the methods recommended have to be modified to suit each individual case. Fur-

thermore, the needs which have to be met are often so contradictory and so incompatible that, in many instances, one has to be content with a compromise, which will no doubt be the lesser of two evils from which to choose. In reality, restoration—in the strict sense of the term—is impossible when it is a matter of dealing with damaged paintings, and, whatever form it may take, it will never be more than an attempt, an approximation.

The success of a restoration depends less on the method employed than on the experience, skill and conscientious work of the person who applies it. The treatment of valuable paintings should therefore be entrusted only to specialists of unquestionable repute or recommended by a national museum, or by a central organisation fully competent to propose a properly qualified restorer.

Qualifications of the Restorer.

94. — Every museum and every art gallery should have at least one good restorer on its staff. Today, it is possible to find first-rate experts, thoroughly acquainted with the technique of the conservation and restoration of paintings; but large institutions are often obliged to seek the services of various specialists and must be able to rely on the constant collaboration of at least one or two restorers. The latter should be proficient professionals, possessing a complete knowledge of the different techniques of painting and familiar with all the materials used by artists. They should also be thoroughly initiated to the technique of the old masters (this knowledge will be acquired, in part, by executing copies), to the history of art, besides an indispensable training in chemistry; needless to say, they should also have practical experience of all the processes of cleaning and restoration, including re-lining, the treatment of wood, etc.

The Professional Training of Restorers.

95. — We here touch upon the complex problem of the professional training of restorers, which has already formed the subject of an enquiry conducted by the International Museums Office (1). The recommendations and suggestions formulated by the most highly qualified authorities on this question point to the necessity of organising, in the leading museographical institutions, systematic courses of instruction planned for selected pupils who already present certain guarantees, not only from the point of view of knowledge and personal talent,

(1) See *Mouseion*, Vols. 19, 20, 21 and 22.

but also from the standpoint of moral qualities. On the completion of these courses, diplomas would be awarded, as is already done in some countries in connection with the professional training of museum curators.

This idea originated in the principle that one of the gravest dangers which threaten works of art lies in the treatment to which they are subjected by incompetent restorers. Such a state of affairs—which it is surprising to see prevailing in these days when, compared with the past, far more importance is attached to the value and significance of these irreplaceable documents—is undoubtedly due to faulty organisation, which might easily be remedied if systematic action were taken by the responsible departments. It is clear that it is no longer admissible that the community should derive practically no benefit from the experience of the expert restorer and that the results of this kind of work should be jealously guarded or, at most, communicated to a few initiated persons. It has also been pointed out that restorations were too often entrusted to painters who lacked the ability to produce original paintings and devoted their time to this work of reconditioning without any previous training. Some of them, no doubt, have acquired considerable skill, but very often to the detriment of the works on which they carried out their first experiments. It may be argued that there will have been no serious loss if these early experiments were made on paintings of no value. But, as repeatedly pointed out in these pages, it is rarely possible to decide with certainty that a work is valueless until it has been minutely examined and cleaned with all the necessary care and observance of scientific principles. The number of masterpieces that have been permanently spoiled because nobody suspected the name of the author therefore makes it imperative that the greatest caution be exercised in the choice both of the restorer and of the methods adopted, even for paintings judged to be of only secondary value.

Until this restorer's diploma has been generally introduced, we may envisage the rational training, in the laboratories attached to the leading museums, of one or two restorers judiciously chosen for the qualifications indicated above.

Technical Staff.

96. — Besides the professional restorers, the technical staff of a gallery should include a re-lining expert. This expert would work in a special workshop and would also be entrusted with the treatment of blistered paintings and the stopping of holes, for the less serious cases.

A third workshop, fitted up for all kinds of cabinet-work, would be occupied

by a wood-working expert; he would deal with panel paintings and should therefore be a joiner or cabinet-maker with many years' experience of wood, plywood, etc. The re-lining expert and the wood-worker should work in close collaboration, under the supervision of the restorer, and each would be required to train his own apprentices.

The physico-chemical laboratory should, of course, be situated close to these workshops, so that the restorer may easily pass from one to the other to give his advice, carry out his investigations and generally help the staff working there.

Close collaboration should also be established with other official laboratories or industrial research centres.

Functions of the Restorer.

97. — The restorer forms the natural link between the art historian (gallery director, professor of history of art) and the specialist in the physical and chemical sciences. After his weekly visits to the museum galleries, he will draw the curator's attention to the paintings which, in his opinion, need the most urgent treatment. But though a really qualified restorer must be given the greatest possible latitude in the choice of the methods to be applied, it will be for the curator to decide how far a particular case of restoration is to be carried; the restorer should, for his own sake, invariably arrange for a member of the museum staff to be present as a witness when he is engaged on particularly delicate work.

In this connection, the old-fashioned custom of workshop secrets and mystery has fortunately given way to frankness and to the international exchange of experiences, as was shown, for example, by the International Conference held in Rome in 1930 under the auspices of the International Museums Office. Paintings as well as the restorer's profession have had everything to gain since the problem is being discussed in this atmosphere of mutual confidence and since journals such as *Technische Mitteilungen*, *Technical Studies* and *Mouseion* are publishing the hitherto jealously guarded formulas, together with information on the improvements introduced into modern technique. In this respect, restorers are now lagging only a short distance behind the medical profession.

The Task of the Restorer.

98. — The task of the restorer may be divided into two parts: first, the conservation or preservation of more or less sound paintings; second, the restoration

or reconstruction properly so called of unsound or damaged works: filling in of lacunæ, retouching, etc. In its wider sense, the word "restoration" comprises both aspects of the work.

Nowadays, few people will deny the need for taking measures to preserve and conserve paintings (although, in some galleries, there are still certain inestimable masterpieces which are decaying because nobody dare touch them). When a few years ago some European galleries were asked for permission for the taking of X-ray photographs of a large number of their pictures, for an American research institution, the main objection raised was that the paintings might be damaged while being moved. The request was, however, granted in respect of a certain number of paintings and the most notable discovery made when they were taken down from the position which they had occupied for numbers of years was that many showed dangerous blistering and other signs of deterioration which had been overlooked during the successive inspections *in loco*; it was therefore possible to arrest the process of deterioration and to treat the paintings before it was too late.

And yet there are still quite a number of people who look upon these measures of restoration with a certain mistrust; it is true that, up to fairly recent times, many errors were committed in the execution of this work. It was, however, because the appropriate conservation measures had not been taken that it was later necessary to resort to restoration on a larger scale and, in many cases, the cleaning, retouching and repainting operations were carried too far.

Principles of Cleaning and Stripping.

99. — A few remarks concerning these two operations are here necessary in order to define their scope and principle, although we shall return to the question in the chapters dealing with the practical methods that should be adopted.

In contrast with *dabbing* (removal of the superficial coating of dirt), *cleaning* is generally understood to be the removal of the varnish. The complete removal of the varnish, retouching and repainting is generally known as *stripping*.

With regard to the actual principle of the operation, details of which are given in Chapter XII, a fundamental question arises: should dark varnishes and other later additions be removed from old masterpieces?

The standpoint of the scientist and of the artist of today may briefly be expressed as follows: the higher the artistic and colouristic value of a painting, the

less excuse will there be for allowing such disfiguration to subsist—provided, of course, that it can be removed without danger to the original.

The day has passed when there was some justification for the belief that the cleaning of any picture was dangerous, just as a surgical operation endangered the life of a patient. But with improved modern methods, it may safely be said that the great majority of paintings can be cleaned without any danger. The primary interest of the artist and of the scholar lies essentially in the original condition of a work.

On the other hand, one can to a certain extent understand the feelings of the owner of a painting who venerates that "patina" (which goes so well with his antique furniture) still more than the intention of the master.

At any rate, and whatever point of view may prevail in a given case, *the aim of the restorer is to save and respect every fragment that is left of the original work and to bring it out to its fullest advantage.* There can be no fixed rule as to how this object is to be achieved. The most appropriate solution must be sought, with the help of the formulas and methods available for each individual case.

Gaps.

100. — The second important question to be considered is whether and to what extent the *gaps* in a painting should be replaced; the general aspect of this question was discussed in outline in Chapter I. We have seen that this is a matter of taste and judgment, and sometimes of tact. The solution will be quite different according as it is a question of a narrow crack, the disappearance of a large portion of the subject, or even the total loss of half the painting. In the latter case, the picture must be left as it is and exhibited as a fragment, treatment being confined to the necessary measures of conservation.

The measures taken will depend also on the purpose one has in view, or, more exactly, on what must be done, according to whether a picture is to be preserved for the sake of the subject, for its artistic value, for a museum or for a private owner.

It has recently been advocated that paintings should be left as they are and exhibited with all their 'lacunæ" unconcealed. In support of this theory, it has been argued, as mentioned in Chapter I, that sculpture has long been exhibited unrestored. This argument is, however, invalidated by the fact that there is nothing whatsoever in the place of the missing portions of a piece of sculpture, whereas at the spot where a piece of paint is missing there is a patch

of a definite form and colour, which plays a positive and unfortunate rôle in the picture as a whole.

Treatment of Gaps.

101. — There are some who maintain that after stopping a patch which has lost its paint-layer the patch should be left *white*. It is obvious that even a few small white stoppings will be sufficient to ruin the unity of a picture: as the result of a well-known optical illusion, a white patch on a dark ground appears to be larger than a darker patch of the same size. This may be proved by a simple experiment: as soon as the white patch is darkened it immediately appears smaller.

There are many ways of lessening the disturbing effect of the lacunæ without concealing them completely. Some curators have had the fillings toned in what they call "neutral grey". A neutral grey in a picture, however, is a fiction: it will always assume the complementary tones of the neighbouring colours, thus introducing an alien element into the painting.

Another method, which seems to be more satisfactory, consists in painting the patch in the same brownish colour as the local underpaint, such as may be seen in a number of old pictures. This result may be obtained either by reconstituting the contour, or by leaving the patch flat.

An alternative solution would be to paint the patch in the same tone (but lighter) as local underpaint, that is to say in the same tone as the surrounding colour but just a shade lighter.

Yet another method would be to match the surrounding colour without completing the contour.

These compromise methods are more suitable for primitives than for pictures of later periods where the naturalistic tangibility plays a greater part. But even if the colour and the modelling were absolutely matched, it would still be possible to make the retouching distinguishable if this were desired. They could, for example, be left either rougher or smoother than the original part of the painting, or they could be kept at a slightly lower level than the general surface of the paint-layer itself.

Whichever method is adopted, the filling-in should always be adjusted to the æsthetic and technical qualities of the picture; for example, no patch of lesser purity or inferior transparency than the remainder of the painting should be introduced.

A discreet restorer will always find some compromise which will please both the public—which merely wants to enjoy paintings without any disturbing factors—and the purist scholar, who, in addition, regards the pictures as objects of study.

Contributions made by the Auxiliary Sciences and Modern Technique.

102. — By way of conclusion, the progress made in recent years in the fiedl of picture restoring may be summed up as follows:

The methods of investigation, and the measures calculated to prevent the deterioration of paintings, as well as the means adopted for their conservation, have been greatly improved.

The more it was realised that it was impossible to replace completely any portion missing from an old masterpiece, so the sense of responsibility developed and greater and greater care was taken in the cleaning of paintings. Moreover, better and safer solvents have been found.

Modern technique in the matter of reproduction has provided the technician, the curator and the historian with systems of recording that have proved entirely satisfactory.

Retouching is now done rather in the manner of inlay work, great care being taken not to cover any portions preserved in the original paint (as opposed to the former and coarser practice of overpainting more than was necessary).

A more thorough knowledge of the style and technique of the old masters has led to a corresponding improvement in retouching, this work now being done in the same semi-transparent or glazing layers as those of the original.

The colour now used for retouching will, in all probability, not darken like the oil-colour formerly used. (Tempera is now used for the under-paint—resin and wax colours for the finishing glazes).

Tinted varnishes, which were often used for veiling unsuccessful retouching, have consequently become obsolete and have been superseded by non-darkening and easily removable varnishes. The artificial mellow toning—''patina'' or ''golden glow''—so often given to pictures during the XIXth century, is no longer tolerated, neither from the scientific and æsthetic standpoint, nor from the hygienic standpoint.

Retouching can now be done with colours which can easily be removed without any danger to the original.

Retouching which matches too well with the colours of the original no longer constitutes a problem, since the advanced methods of detection now available make deception impossible.

Whatever method may be adopted and provided that no damage of any kind is done to the original, the various systems of recording will always furnish the necessary data for ascertaining the condition of a painting before and after stripping and before retouching and additions.

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In the various sections of this chapter, we have merely outlined the programme of restoration work, indicating the conditions which curators and owners of works of art are entitled to lay down when they entrust an object to the care of a technician, and pointing out the guarantees offered to both sides by the present-day conception of restoration and by the scientific processes now used. The chapters that follow will examine in detail the processes and formulas which, for each of the constituent elements of a painting, have proved successful in the different operations included in the expression "restoration".

CHAPTER XII

MALADIES AND TREATMENT OF THE VARNISH LAYER

Preliminary Observations.

103. — The functions of the varnish are twofold: 1) To protect the paint from the pernicious influences of the atmosphere; 2) To restore to tarnished or sunk-in paint the luminosity and transparency originally intended by the artist. A third function which some people attribute to varnish, namely to give a general tint to a painting, holds good for only a limited number of pictures. It can safely be said that, in most cases, the yellowish tint of the varnishes to be seen on old paintings was not intended by the artist.

Some early Italian gold grounds were originally covered with an intentionally tinted varnish. Before the colourless and non-oily spirit varnishes were invented many pictures had been varnished in their time with oil varnishes which, though unintended by the painter who applied this treatment, had a yellowish tint in themselves and went on yellowing with age. Deliberately tinted varnishes seem to reappear only in the XVIIIth century and remained in vogue throughout the XIXth century.

It is not known exactly whether all paintings in early times were intended to be varnished. Some, perhaps, did not require the varnish to complete the optical effect of the luminosity and transparency of the paint, while others were probably intended to retain a certain mat effect. Nowadays, all paintings need some kind of protective layer, firstly because the atmosphere of industrial towns is vitiated to such an extent that it has become more and more dangerous to paintings, and, secondly, because the majority of old paintings have lost their original optical aspect as the result of some kind of cleaning, deterioration or natural ageing phenomena: the continuity of the binding material has suffered and has to be restored by varnish.

The most common and most disturbing changes occurring on pictures —changes which seem to affect the paint layer itself—are, in reality, fortunately confined to the varnish layer and can be remedied fairly easily.

A. — COMPOSITION OF VARNISHES

Solvents and Diluents.

104. — All varnishes consist of a substance which has the property of forming a film on drying, such as resin or wax dissolved in a suitable solvent. When oil is used as a solvent, the addition of a thinning substance, called a diluent, is necessary, and it is important that this substance should not be of such a nature as to soften the paint-layer; moreover, it should evaporate completely after application.—Examples: rectified oil of turpentine; rectified oil of petroleum; rectified oil of lavender.

In order to satisfy the above requirements, it is important that the solvent should be thoroughly rectified and free from moisture, otherwise it may cause precipitation when added to the varnish. Alcohol, which is a common constituent of shellac varnishes, is not to be recommended owing to its high solvent power and the consequent danger of damaging the paint.

Resins and Waxes.

105. — Resins are found in their natural state in certain vegetable tissues from which they are extracted either by heating or by the action of solvents. They are divided into three classes, according to their solubility, and are called respectively: balsams, soft resins and hard resins, the last-named sometimes occurring in a fossilised state.

a) *Balsams or resins.* — Examples: Copaiba balsam, Canada balsam, Venice turpentine.

b) *Soft resins.* — Examples: Mastic, dammar, sandarac.

c) *Hard resins.* — Examples: Copal, amber.

a) The balsams are unsuitable for picture varnishes.

b) Varnishes made from soft resins are prepared by dissolving the latter without the aid of heat in a suitable solvent such as turpentine.

To prepare a mastic varnish, for example, the lightest coloured fragments of the dried resin are selected; these are placed in a small net bag and immersed in a wide-mouthed jar containing doubly rectified turpentine which must be free from moisture. The jar may be closed with a waxed cork stopper. The resin gradually dissolves, forming a clear solution which can be decanted after

a few weeks. The varnish is then ready for use. The actual strength of this solution is immaterial, provided it is thin and as clear as water.

c) The hard resins are insoluble unless previously melted. Copal, for example, is made into oil varnish by melting it at a high temperature; the oil is then incorporated and, as soon as the mixture has cooled, the diluent is added in sufficient quantity to give the required consistence. Copal varnish cannot be prepared satisfactorily by the amateur.

Beeswax and paraffin wax are very stable substances, with optical qualities which distinguish them from the resins.

General Types of Varnishes.

106. — *a*) Oil varnish, artist's copal varnish.
b) Spirit (shellac) varnish, artist's mastic varnish.
c) Wax dissolved in turpentine.

The presence of drying-oil in the protective film confers greater mechanical strength than is obtainable with spirit or turpentine varnishes, but at a slight sacrifice of colour (yellowing). The film darkens more readily than that of spirit or turpentine varnishes and eventually becomes quite insoluble.

The film given by a turpentine varnish consists solely of resin; it is transparent and highly refractive and has the great advantage of not becoming insoluble with time, so that at any later date it may be easily removed without damage to the paint layer beneath. Soft resins, on the other hand, are brittle and do not confer the same mechanical protection as those containing oil, but they go yellow with age more slowly.

In recent years, the use of waxes as constituents of picture varnish has become more and more general.

It is always preferable to use the wax dissolved in turpentine and to apply the solution over a dried film of resin varnish, rather than to attempt to make a mat varnish by incorporating the wax in the varnish formula. By this double procedure, the virtues of both layers are unimpaired, whereas the mixed varnish is always of doubtful protective value. Wax should be applied in the thinnest possible film, and if desired it may be polished a few days later with a silk handkerchief, so that the surface will not be sticky and retain dust. The only exception to this generalisation regarding mixed varnishes is the addition of a little oil to mastic spirit varnish, as is commonly done to counteract the brittleness of the film. Given normal conditions, mastic varnish affords adequate pro-

tection to the paint-layer for some 30 to 50 years, before it becomes yellow and disfiguring and ceases to afford protection.

Wax, as has been stated, lasts remarkably well and, of all surface films, seems to afford most protection against the disintegrating influences of moisture and of the noxious gaseous impurities in the atmosphere of towns.

See also the sections describing the various methods of varnishing (121-130).

B. — MALADIES AND TREATMENT OF VARNISHES

Sinking in and wearing off.

107. — It frequently happens that a thin layer of varnish no longer fulfils its functions because, during the process of drying, the solution has sunk into areas of the painting that were too dry or too rough. This is the phenomenon generally called "sinking in".

When it occurs, the picture looks as if it had not been varnished; it assumes an unsightly and dull aspect, and the dark portions necessarily turn several degrees lighter.

In many cases, it is impossible to distinguish between sinking in and the wearing off of the varnish due to abrasion, etc.

As a rule, neither of these two defects can be remedied without applying a new, and perhaps a thicker coating of varnish. (See D.—Methods of Varnishing).

Blooming.—Mould.

108. — A very widespread and disfiguring phenomenon is the so-called blooming. It takes the form of a whitish opalescent haze on the surface of the varnish, the darker areas of which appear bluish. One of the causes is dampness during or after the application of the varnish. Very often, it grows worse and penetrates more deeply into the varnish layer, sometimes completely changing the visibility of the painting.

Treatment. — A varnish prepared and applied under good conditions (see D) and kept in a constant temperature is less liable to bloom, but the blooming cannot always be avoided because it is sometimes due to physical or even chemical influences that are difficult to determine.

In mild cases, polishing with some soft material, such as fine wool, silk or cotton-wool, will remove the blooming, but it generally reappears after a time.

A more lasting effect is obtained by wiping the surface of the varnish with a swab of cotton-wool wrapped in a piece of very soft chamois and soaked in turpentine containing about 20% of mastic varnish and 2% of castor oil. It

is difficult to apply this treatment without leaving streaks, and the surface will remain sticky for some time. A painting so treated should be protected against dust and other atmospheric impurities and kept in a room of constant temperature.

If the blooming continues to penetrate, all the strata attacked can be removed by one of the dry removal methods (see § 127), after which a new varnish must be applied.

Another kind of malady due to dampness but of a more visible character is known as *mould*, a growth which covers the painting with a light white film.

Mould may be merely superficial and can be removed by the same treatments as those indicated for the removal of bloom.

Disintegration.

109. — A general disintegration of the varnish, manifested by an unsightly grey aspect and an optical change in the colours, sometimes takes place without previous blooming and may be due to several causes. The treatment to be applied in such cases is given below.

Crackle.

110. — One form of disintegration is known as crackling. This may be either identical with the crackling of the paint-layer, or occur independently of it and appear in the varnish alone.

In mild cases, it is not always necessary to adopt any measures, but if they become too serious or if the varnish layer deteriorates so badly that it no longer affords sufficient protection, the continuity of the varnish must be re-established.

As a general rule, it is better to remove completely a varnish that has disintegrated than to attempt to reconstitute it.

However, when a restorer is not available or when a cleaning substance offering every possible guarantee of safety is not at hand, or when, as is very rarely the case, an old original varnish seems to be present, the *regeneration* method (see § 112) may be adopted, but its effect does not seem to be lasting.

14. CLEANING A PAINTING WITH A SMALL SWAB OF COTTON-WOOL WOUND ROUND A STICK.

In the majority of cases, a new varnish layer applied on top of an old one that has disintegrated in some way will very soon deteriorate as well.

Pulverulence.

111. — The last stage of disintegration is the pulverulence or "chalking" of the varnish. Needless to say, this cannot be remedied and nothing remains but to remove what is left of the varnish layer (see C.—Removal of varnish).

Regeneration.

112. — In the XIXth century, Professor Pettenkofer invented the following method of regenerating varnishes and disintegrated pigments:

The bottom of an air-tight box of exactly the same size as the picture is lined with thick felt; this is evenly sprayed with alcohol. The picture is laid face downwards on the box, like a lid, so that it rests only on the edges of the box. The sides of the box should be about 2 inches high.

A preliminary test should be carried out on a small portion of the picture as follows: A round hollow lid (about 5 mm. deep and 1 cm. in diameter) lined with felt charged with alcohol is placed over a disintegrated area on the edge of the picture and the result checked at intervals of not more than 10 or 15 minutes.

Sometimes, the varnish will not react at all, or too little, owing perhaps to the presence of an ingredient such as wax; in such cases, total regeneration should not be attempted.

Generally, however, the circular area will become shiny and transparent, frequently after three or four minutes.

This test will serve as an indication of how long the regeneration will take; it also indicates the moment when the operation may be regarded as accomplished: e.g. when the shiny spot left by the lid is no longer distinguishable from the rest of the surface.

This method, should, of course, be employed only by very experienced restorers, and even then with scrupulous care, because some paintings (those containing resin in their binding medium, for example) react very quickly to this treatment and would easily be destroyed if exposed for too long to the action of alcohol vapour.

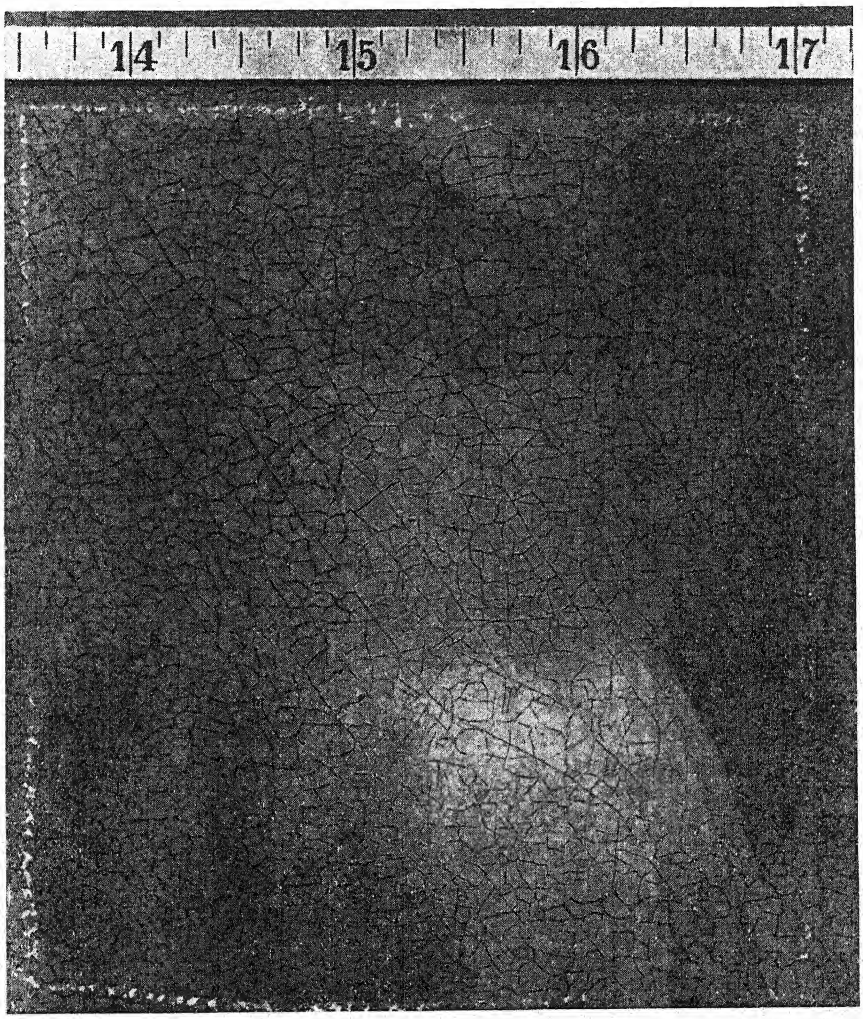
Copaiba balsam which, according to Professor Pettenkofer might be used

15. DETAIL OF A COROT, SHOWING IN THE UNCLEANED PORTION OF THE SKY A CLOUD EFFECT NOT INTENDED BY THE ARTIST AND DUE TO THE ACCUMULATION F DIRTY VARNISH IN THE FURROWS LEFT BY BRUSH STROKES.

before the regeneration, is no longer used, because of its instability; it is, in fact, quite unnecessary.

The whole process should, of course, be carried out in a dry and warm room entirely free from draught.

As a rule, as soon as the regenerated varnish has thoroughly dried and hardened again, a new layer of varnish should be applied.



16. DETAIL OF A DUTCH STILL LIFE. CRACKLES ACCENTUATED BY THE ACCUMULATION OF DUST, SOOT, ETC. IN THE LIGHTER SQUARE THE DIRT, BUT NOT THE VARNISH, HAS BEEN REMOVED; IN THE WHITE PATCH, THE DARKENED VARNISH HAS ALSO BEEN REMOVED. (SCALE GRADUATED IN INCHES.)

C. — REMOVAL OF VARNISH

Definition.

113. — The removal of varnish (French: *dévernissage*; German: *Firnissabnahme*) is, in English, generally referred to as *cleaning*—the literal translation of *nettoyage* in French, and of *Putzen* in German. To avoid misunderstanding, when it is simply a question of removing the dirt which covers the varnish, one should use the terms *surface-cleaning*, *wiping* or *washing* (German: *oberflaechliche Reinigung*) as opposed to *cleaning*, etc.

On the other hand, the current English term for removal of varnish and retouching, in short everything that does not belong to the original, is *stripping* (French: *dépouillement*; German: *Vollständige Reinigung* or *Freilegung des Originals*).

Principles.

114. — The hygienic reasons for the removal of varnish have been dealt with in a previous chapter, and the moral, æsthetic and scientific points of view in the foreword when referring to the processes of restoration. We may summarise as follows:

Varnish should be removed unless more serious reasons prevail:

1) When it is in a bad condition;

2) When its colour disfigures the original intended colour scheme of the painting; in other words, when the optical effect of the paint is altered by the varnish;

3) When the restoration of the paint-layer requires it.

As already stated, one rarely finds an original varnish on an old picture. In the great majority of cases, old pictures are covered with a varnish that has darkened with time and often deliberately tinted either to veil unsuccessful retouchings or to give to the picture that "golden glow" so much admired during the XIXth century.

But whenever there is reason to assume that the varnish was applied in the master's studio, and if this varnish is in good condition, this should, of course, be left, and everything should be attempted to reconstitute it if it has suffered from one of the minor impairments mentioned above.

17. EXAMPLE OF CLEANING. — THE DARKENED VARNISH HAS BEEN REMOVED FROM THE LIGHT PATCHES ON THE MAN'S FACE AND THE DOG'S HEAD, AND ALSO FROM THE BACKGROUND ON THE RIGHT, THE DARK BORDER ROUND THE TWO PATCHES IN THE UPPER PART OF THE PICTURE SHOW HOW THE CLEANING SOLVENT HAS REVIVED THE VARNISH BY RESTORING ITS DEPTH, WHEREAS IN THE UNCLEANED PORTIONS IT IS MAT AND MAKES THE DARK AREAS APPEAR LIGHTER.

Preliminary examination.

115. — The removal of the varnish should never be started until every loose particle of the painting is safely fixed and until the painting has been carefully examined and all the data recorded (see Chapters II and XIII).

Ultra-violet rays are particularly useful for the examination of varnishes and especially as a means of control during the process of cleaning. Of course, one should never venture to remove all the varnish in ultra-violet light only. The strongest daylight, sunlight if possible, or very powerful artificial light must be used (750 W minimum).

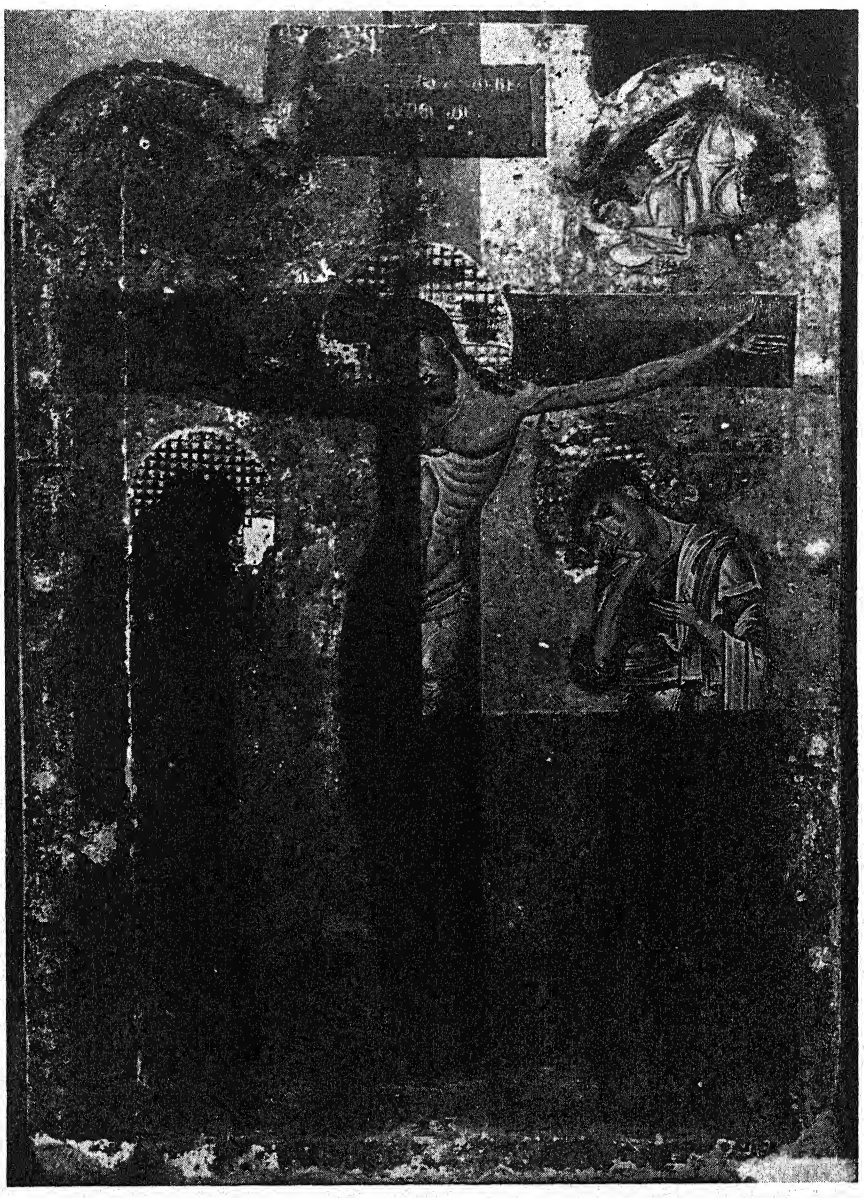
Every possible precaution must be taken in this most delicate of all procedures of restoration, including the presence of a witness (the owner of the picture, if this can be arranged). It should here be stressed, however, that no layman, and even few specialists, would be in a position to interpret correctly what happens during the process of cleaning. Only the man actually engaged in this work is able to sense how far he is penetrating towards the original paint-layer, for not only the eye, but also the touch, and even the ear, play a part in the control of the progress made. The experienced cleaner feels when he is passing from a soft and sticky coating of varnish or retouching to a harder and rougher original layer.

Half-way Cleaning.

116. — In view of the great danger of over-cleaning, it is often suggested that, in cases where it is necessary to disturb the varnish, only the upper portion of it should be removed, leaving the remainder before getting dangerously near the original paint. This sounds a simple and sensible suggestion, but it can very rarely be followed in actual practice; it is possible only when an extremely thick coating is present on a very smooth picture, and then only when the varnish reacts uniformly to the cleaning all over the surface.

In the majority of cases, many parts of the picture would remain darker than others and this would often result in a serious interference with the balance of the painting. Art galleries are full of pictures which show that some cleaner has indulged in this kind of "negative painting": portraits with brilliant, clean faces, yellow hands, brown linen, etc.

Many paintings have a rough texture due to the canvas grain or the brush-work, and it is obvious that, in the process of cleaning, the salient ridges of the surface will often become quite clean and bright while the hollows will remain



18. CRUCIFIXION, XIIITH CENTURY, ARTIST UNKNOWN (S. DOMENICO MAGGIORE, NAPLES); PHOTOGRAPHED IN THE EARLY STAGE OF CLEANING.

dark or become even darker through dirt being rubbed into them. The disfigurements caused in this way are often quite serious and sometimes even interfere with the presentation of the subject; for instance, a young face may become old and wrinkled; a clear sky may become heavy and cloudy, etc. (see Fig. 15).

Some people contend that an accumulation of dark varnish gives interesting emphasis to the original brush-work of the master, but this emphasis is so casual that it destroys more of the original effect than it accentuates. The kind of basket-work texture to be seen in most Rembrandts nowadays was certainly far from the master's intention.

We know of many Rembrandts, Renoirs and so on, which have thus been changed by half-way cleaning, where the high lights now form dark spots because the dark varnish accumulated in the roughness of their brush strokes has not been removed.

It goes without saying that particular skill and patience is necessary to clean these sometimes very narrow furrows and recesses.

From the technical point of view, complete varnish removal is occasionally more dangerous than a half-way treatment, but from the artistic and scientific standpoint, an incomplete cleaning is nearly always more dangerous. (For the dangers of cleaning, see Chapter XIII, "Removal of Repaint").

The essential points of the procedure of varnish removal are dealt with in the sections on the removal of re-touchings (Chapter XIII).

The much-talked-of so-called *dry removal* of varnish, a method which consists in starting with a grain of resin and rubbing off the varnish with the tip of the finger, is very rarely useful (see "sinking-in" of the varnish-layer). On perfectly smooth panels painted in pure oil or in *tempera*, this method may give good results, but in these cases a "liquid" cleaning would be just as safe. Where it would be dangerous to use a solvent, for example on a paint containing resin, the dry cleaning process would be still more harmful, for the paint would come off with the varnish, the pulverised varnish making it impossible to see what is taking place.

Cleaning Solvents.

117. — Cleaning liquids usually consist of a mild ingredient, which acts as a restrainer, and the actual solvent, which is stronger. The most common mixture is made up of essence of rectified turpentine, as restrainer, and alcohol,

19. DETAIT OF A RENOIR. ACCUMULATION OF DARK VARNISH IN THE HOLLOWS AROUND THE IMPASTATION. THE LATTER WAS DEPRESSED IN THE COURSE OF A PREVIOUS RE-LINING. THE PHOTOGRAPH, TAKEN BEFORE THE DARK VARNISH HAD BEEN COMPLETELY REMOVED, SHOWS THE EFFECT OF HALF-WAY CLEANING: ACCUMULATION OF DIRTY VARNISH IN THE FURROWS LEFT BY THE BRUSH IN THE IMPASTATION.

as the strong solvent. The turpentine is now advantageously replaced by petrol (highly rectified spirit of paraffin, boiling point about 160° C.). Pure ethyl alcohol is preferable to other forms of alcohol because it mixes better with turpentine or paraffin. We give here a short list of the chief cleaning substances, beginning with the weakest:

1) Petrol or benzine; boiling point 40 to 60° C. (not to be confused with benzene or benzol). This does not remove most of the varnishes, but leaves them a little duller; sometimes useful for removing surface dirt and grease before revarnishing; contrary to common belief, it is a weaker solvent than 2 and 3, perhaps on account of its rapid evaporation.

2) Petrol (see above); boiling point about 160° C. As a rule, dissolves only

fresh varnishes and balsams, unless applied by a long-acting process in the form of a wax paste or on soaked blotting-paper.

3) Turpentine. Almost identical in action to 2.

The following substances cannot, in many cases, be used alone without dan-,ger but are very useful in combination with 1, 2 or 3, or for special cases:

4) Xylol. Boiling point 130-135° C.

5) Benzol. Boiling point 120-160° C. Dangerous for most pictures less than 100 years old, but safe for many older paintings. Though weaker in action than alcohol, benzol intensifies considerably the solvent power of alcohol when added to it.

6) Acetone. Boiling point 55-65° C. Powerful, but indispensable, especially when attenuated by some restrainer for dissolving certain hard resin- and oil-varnishes.

7) Ethyl-alcohol or methyl-alcohol. Boiling point about 78° C. Some technical books recommend alcohol alone as a solvent for removing varnish in general, but it is a strong solvent and can be used with safety without dilution only on certain types of early paintings.

Acetone and alcohol are similar in solvent strength but their action varies according to the different types of varnish.

There are a great number of solvents to choose from and many of them are extremely useful for special cases.

Proportions.

118. — The action of a solvent depends very largely, of course, on:

the pressure and rubbing action used;

the softness and absorbing power of the material employed (cotton-wool or brush);

the duration of the action (speed of evaporation of the strong ingredient);

temperature.

The stronger ingredient should always be the one that evaporates first.

Experiments with all sorts of complicated mixtures are, of course, possible, according to the type of painting to be treated.

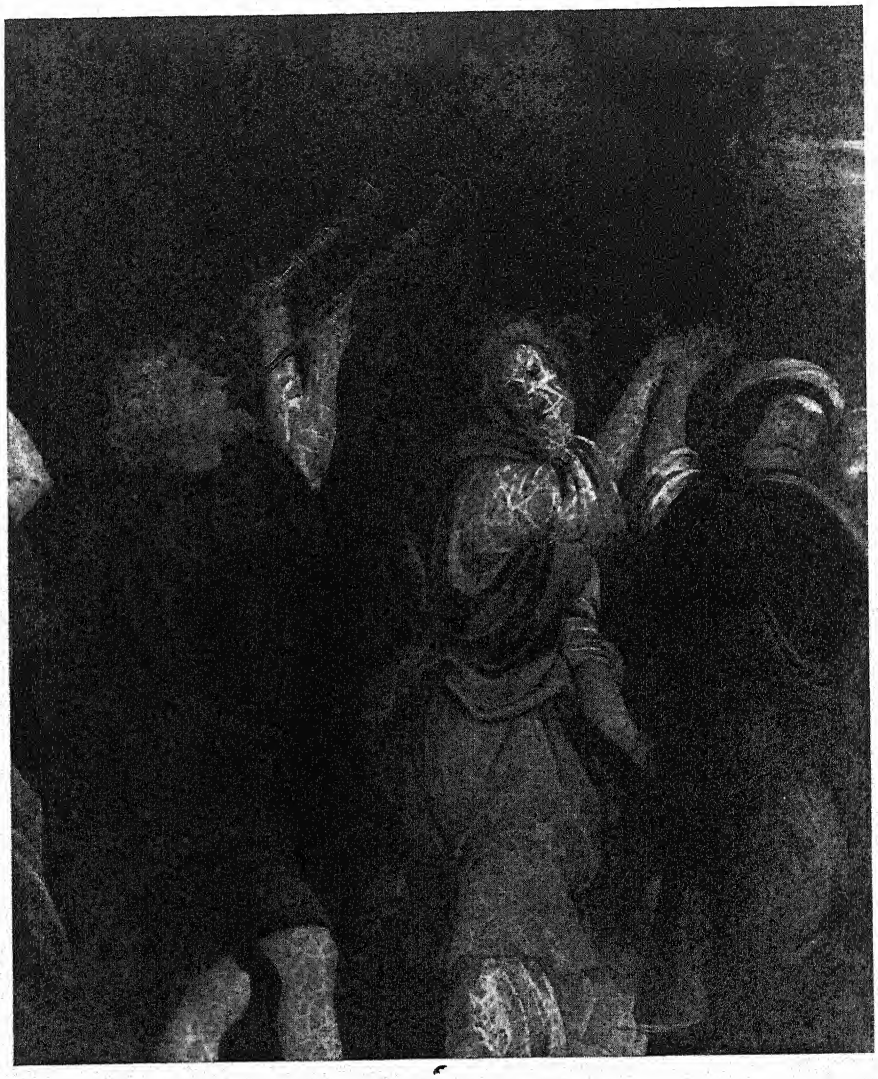
Trial Solution.

119. — In principle, a trial cleaning should be started with a mixture not stronger than:

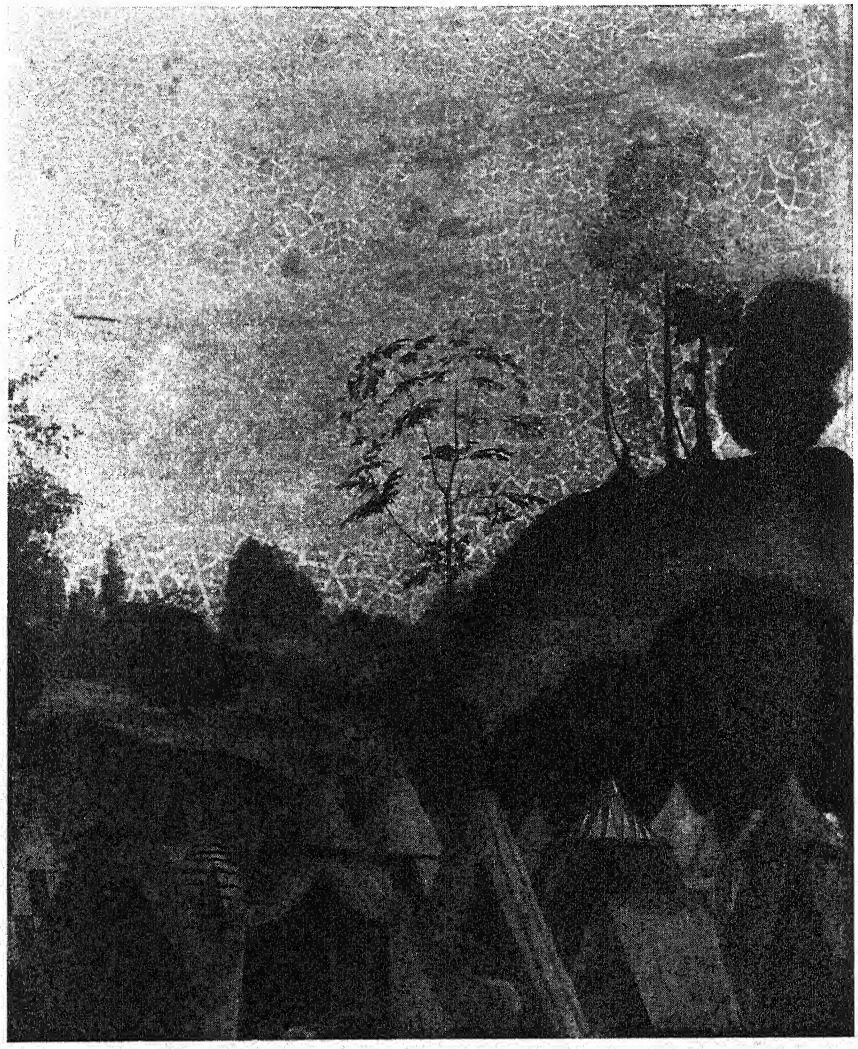
1 part of alcohol to 20 parts of turpentine.

Margin of Safety.

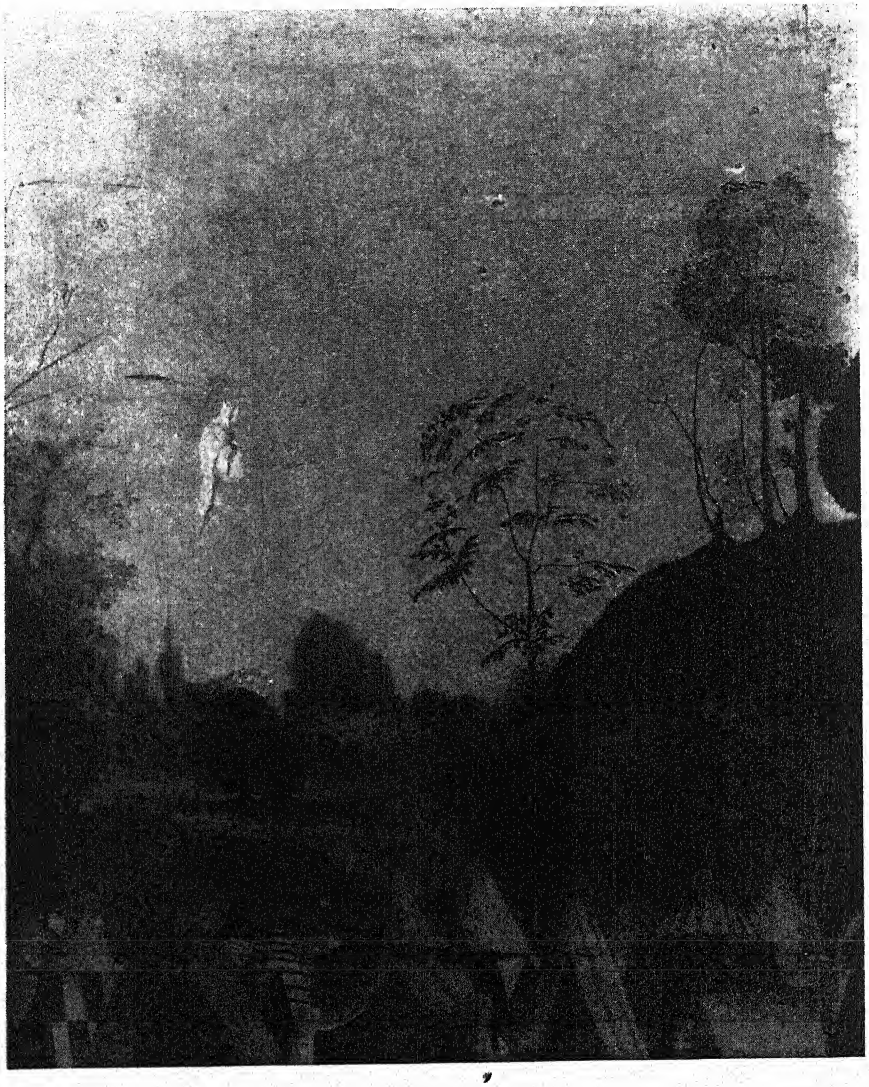
120. — A fundamental rule is to use a mixture that will be just strong enough to remove the varnish. In most cases, there will, of course, be a wide margin between the mixture that will just do this and one that would attack the original paint. With regard to museums, to reassure persons who may fear the danger of cleaning in a given case, it is advisable to fix the *margin of safety* by carrying out a test on the edge of the painting to determine how strong a solution the paint will stand, and to note this in the record. This test can be made on the minute trial area without removing any appreciable amount of paint; as soon as the tiny cleaning swab shows the slightest trace of colour, the test is at an end, and it must be stressed that original paint on an old painting (more than 100 years old) never comes off quickly but only after insistent rubbing, if reasonably adequate solvents are used. In the majority of cases, the margin of safety is much wider than is usually assumed; for instance, where a solution of 1 part alcohol to 10 parts turpentine will suffice to remove the varnish slowly, a mixture of 1 to 1 would still not be dangerous for the original if properly applied. We would again emphasise that even a harmless agent carelessly applied can, under certain circumstances, do more damage than a more violent one in the hands of a skilful and scrupulously careful restorer; for example, solvents slightly stronger than is really necessary, quickly and skilfully used, will often be safer than a weaker one requiring too prolonged rubbing.



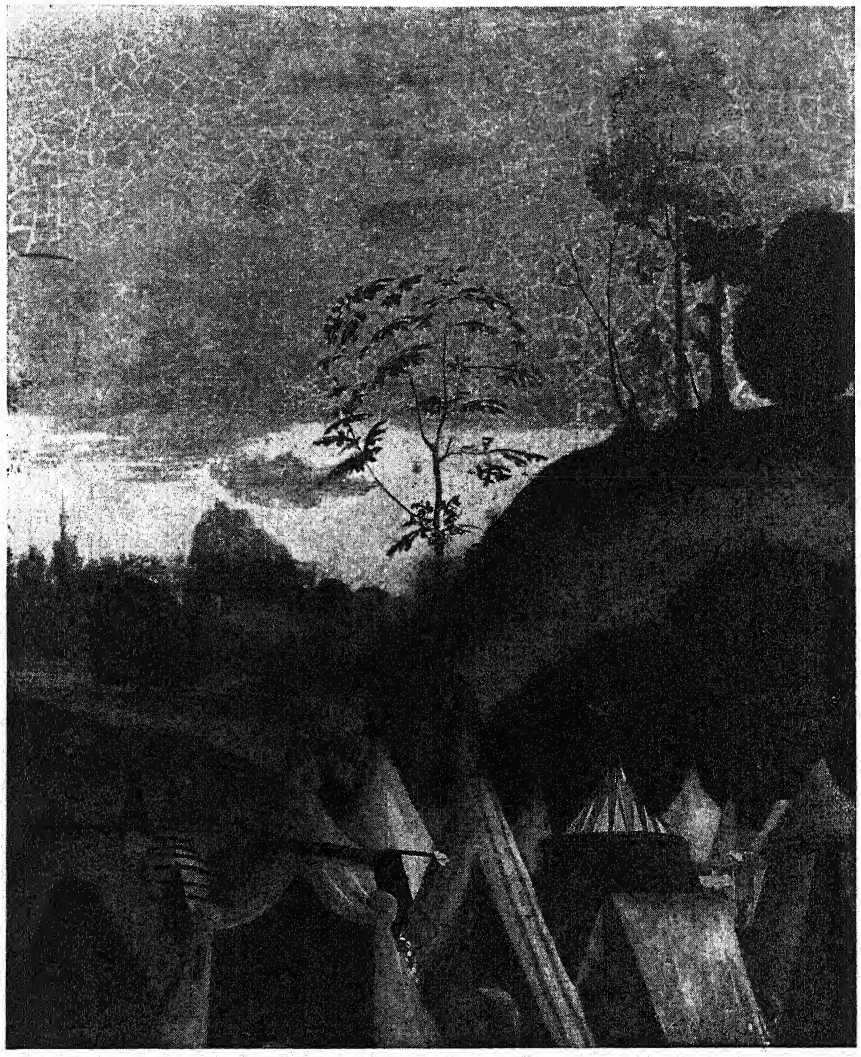
20. DETAIL OF A FILIPPINO LIPPI: " THE GOLDEN CALF ", NATIONAL GALLERY. DETERIORATION NECESSITATING CLEANING: VERY DARK AND SERIOUSLY CRACKLED VARNISH, GIVING THE IMPRESSION THAT THE PAINT HAS CRACKLED. WHEN THE VARNISH WAS REMOVED THE PAINT LAYER WAS FOUND TO BE IN A PERFECT STATE OF PRESERVATION.



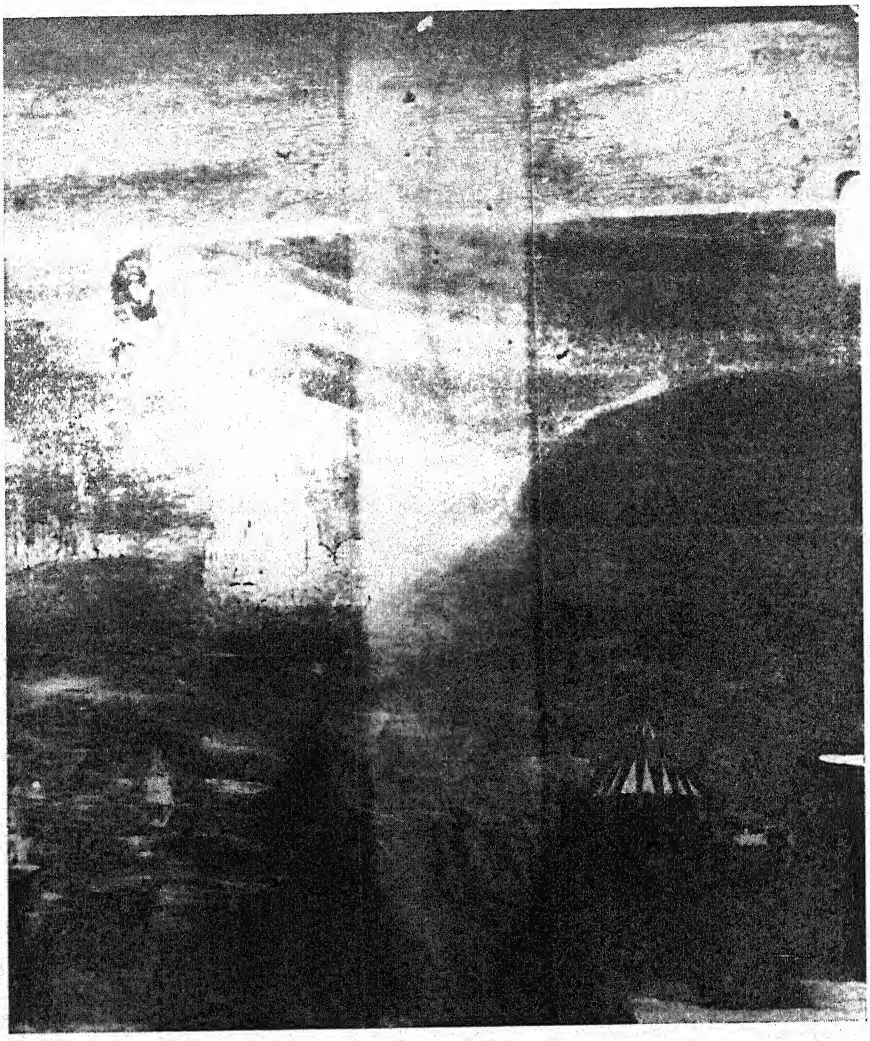
21. DETAIL OF THE SAME FILIPPINO LIPPI, PHOTOGRAPHED BEFORE CLEANING.



22. SAME DETAIL AFTER CLEANING, PHOTOGRAPHED UNDER NATURAL LIGHTING, SHOWING A BETTER CONDITION THAN WAS EXPECTED: THE RETOUCHINGS WHICH APPEARED AS DARK PATCHES IN FIG. 21 COVERED A MUCH LARGER AREA THAN THE ACTUAL DETERIORATIONS, SUCH AS THEY ARE SEEN ABOVE.



23. SAME DETAIL, PHOTOGRAPHED UNDER NATURAL LIGHTING; THE PICTURE HAS BEEN PARTIALLY CLEANED, THE RETOUCHINGS AND THE VARNISH APPEAR DARKER.



24. SAME DETAIL, PHOTOGRAPHED BY X-RAYS, SHOWING HOLES (BLACK SPOTS) IN THE PAINT, OF INSIGNIFICANT AREA COMPARED WITH THAT OF THE RETOUCHINGS.

25. SAME DETAIL, PHOTOGRAPHED BY ULTRA-VIOLET RAYS. THE RETOUCHINGS APPEAR AS DARK PATCHES. THE VARNISH FORMS A SORT OF VEIL AND IT IS ONLY IN THE PARTS WHERE IT HAS BEEN REMOVED (LOWER THIRD OF THE PHOTOGRAPH) THAT THE SUBJECT OF THE PAINTING IS CLEARLY VISIBLE, WITH ITS PROPER VALUES. IN THIS SAME AREA, THE RETOUCHINGS ARE DARKER, WITHOUT THE HAZE OF THE VARNISH. THE CRACKLES IN THE VARNISH STAND OUT BLACK WHERE THEY HAVE PENETRATED TO THE PAINT LAYER.

26. DETAIL OF THE SAME PICTURE, PHOTOGRAPHED BY INFRA-RED RAYS, BEFORE REMOVAL OF THE VARNISH AND RETOUCHINGS, SHOWING HOW THE RAYS PENETRATE THE VARNISH AND EVEN REVEAL A RETOUCHING OVER THE WHITE PATCH. THIS PATCH IS THE PRIMING.

27. DETAIL OF THE SAME PICTURE, PHOTOGRAPHED DURING THE PROCESS OF CLEANING AND BY REFLECTED LIGHT, REVEALING SURFACE IRREGULARITIES, DEEP CRACKLES IN THE THICK VARNISH, FISSURES, HEAVY RETOUCHINGS WITH UNEVEN SURAFCE.

D. — METHODS OF VARNISHING

General Observations and Precautions. *See also* § 46.

121. — Different types of paintings require different varnishes. The earlier pictures executed in size or tempera paint should have a dull finish; before applying the varnish, it must be ascertained whether it will soak into the paint and thus give more translucency and shine than were probably originally intended. If so, a thin coating of clear gelatine (about 7%) or gum Arabic should be applied, and when this is quite dry the wax paste can be applied directly. If a little more shine is wanted, a thin layer of dammar varnish should first be applied, followed by a wax dulling.

Generally speaking, later pictures from the Renaissance onwards can stand a more glossy varnish.

Paintings of the impressionist school are, as a rule, much too brilliantly varnished. They should be rubbed thinly with a layer of dammar varnish (after cleaning) and then dulled with a coating of wax. (See below: E. - Dulling of varnish.)

As already mentioned, paintings should never be varnished until the surface has been cleaned; it is essential that no dust or any kind of greasiness should remain. Petrol (benzine) with a high boiling point is often useful for this purpose.

If an old varnish is present, in sufficiently good condition to be preserved or not to be removed for some reason, but needing another coat of new varnish, one must always ascertain, by operating on a small area, whether the new varnish takes well on the old one and whether it looks well after drying; frequently, the new varnish will appear unsatisfactory over the old one and, finally, the latter will have to be removed and the new varnish then applied.

The varnishing should be executed in a room free of dust, draughts and humidity; the temperature should be maintained at about 25° C. These conditions must be maintained until the varnish has dried perfectly on the picture. Some varnishes containing no oil will take two or three days to dry; others may take several weeks according to the proportion of oil. But the nature and texture of the surface of a picture have a great influence on the drying speed of the varnish. Over wax, for instance, the varnish will take far longer to dry than over a porous tempera surface. A wax coating should always be removed before applying a new varnish. The slight coat of wax resin still to be found on

many paintings treated with this mixture does not, however, prove disturbing as a ground for a new varnish.

The picture, the varnish, the brushes and the sprayer must be of the same temperature, otherwise condensation water is formed and spoils the varnish (a frequent cause of blooming).

Application of the Varnish.

122. — The varnish should be applied as thinly as possible, that is to say, just enough to obtain the desired effect of refreshing the colour and just thick enough to provide the required protection. As all the varnishes which we are able to recommend for the time being darken slightly, the thinner the layer the more satisfactory will be the result. Moreover, a thick layer would submerge the original texture of the painting, which should always remain clearly apparent.

The varnish is usually applied with a soft wide brush. But often a harder kind of brush will be more suitable for working the varnish into the surface in order to obtain a thinner and less shiny protective coating. This can, of course, only be done where no retouchings in wax or resin paint are present that would be dissolved with the rubbing. It is preferable to apply several thin coatings if necessary, rather than to apply one thick coating. The varnish thus spreads more evenly and broad areas are more easily covered; if necessary, isolated parts can be varnished without leaving any visible transition.

If a spray-gun is used, the compressor should be fitted with a good system of dust, oil and water filtering, and a fan-nozzle with a screw for adjusting the outflow of varnish.

Varnishes prepared with petrol instead of turpentine lend themselves better to spraying because they spread more readily on the surface. It is essential that the varnish should form a continuous coating and not isolated drops.

Specific Properties of Varnishes.

123. — Some of the experts of the Special Committee on the restoration of paintings and the application of varnishes at the Rome Conference (1) recommended, for varnishes, the various resins dissolved in turpentine (with the addition of a small quantity of oil); others advocated the use of wax. Each of these substances possesses but some of the ideal properties formulated by the Com-

(1) See *Foreword.*

mittee. From the optical point of view, resin varnish is the best we know of at present, but its protective properties are insufficient.

On the other hand, wax affords the best protection but, in some cases, it is less satisfactory as a varnish with regard to the restoration of the transparency and luminosity of the colours of a painting.

Most of the conditions laid down by the Rome Committee would be fulfilled if paintings were first treated with a resin varnish, which in turn would be protected by a thin coating of wax.

Resin (preferably dammar resin) has only a slight tendency to turn yellow, and even this drawback can be reduced to a minimum, since it is possible to apply it in very thin layers and the effect is completed by the finishing coating of wax.

The coating of resin prevents the accumulation of an excessive quantity of wax in the cracks and hollows of the paint layer—the cause of disturbing effects of opaqueness at these points.

Furthermore, thanks to this previous application of resin, one is no longer tempted to resort to an unfortunate overloading of wax on the parts of the picture which are too dull in order to restore their depth.

Compared with the advantages, the drawbacks of wax, used as a finishing layer, are few in number, namely:

1) The touching of the wax film always leaves a mark, but this is easily obliterated by polishing (1).

2) Before undertaking any revarnishing or regeneration, the wax must be removed; this is easily done with turpentine or benzine.

3) In hot weather, the wax tends to become sticky and to retain dust; this can and must be checked by adding a small quantity of mastic (1).

4) In cold (frosty) weather, the wax has a tendency to become mat owing to crystallisation. This may be remedied by polishing.

Varnish Formulas.

124. — *Resin:* 1 part of dammar resin dissolved cold in 2 parts of turpentine; when dissolved add 3 parts of petrol, or directly 5 parts of French turpentine.

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(1) These drawbacks can be avoided by adding carnauba wax to the formula.

To obtain greater elasticity and permanence, add not more than 5% of stand oil (1), or not more than 2% of castor oil.

Leave the mixture to dry for several days, avoiding variations in temperature.

Wax: Dissolve 1 part of white beeswax in 5 parts of turpentine, in a water-bath at 60° C.

This solution is applied cold, with a very soft brush and as thinly and evenly as possible.

Allow about an hour for drying.

Polish with a still softer brush (of the kind used for polishing silk hats).

If a more glossy surface is desired, it can be further polished with a very soft woollen cloth.

As a general rule, only varnishes which have but a small tendency to darken —mastic or dammar—containing up to 5% of stand oil should be used; but where a slight yellowing would be of no importance and where more effective mechanical protection is necessary, one can apply a thin coating of good copal varnish over the film of mastic varnish when the latter has dried. It must never be applied directly to the paint-layer, for this varnish could never be removed without danger to the painting.

(1) Linseed oil, heated in a vacuum; thick, clear, syrupy, but not oxidised.

E. — DULLING OF VARNISHES

Aesthetic Principles.

125. — One of the chief objections generally uttered against recently cleaned pictures is that they look too "new and polished". It appears that it is not only the bright colours that people object to, but also the too new and shiny varnish.

Such objections are, to a certain extent, justified; in fact, every newly applied varnish, whether on cleaned or uncleaned pictures, should be dulled down in some way in order to reduce that disturbing new appearance and unnecessary reflection from the surface. Many paintings, for instance tempera pictures and a number of modern types of paintings, are not intended with a shiny finish at all and should be kept particularly dull.

Of course, the smoother, that is to say the shinier a varnish, the more perfect is its resistance to atmospheric influences and also the greater its transparency.

The ideal, a perfectly smooth and transparent but still not shiny varnish, does not exist, for by reducing the glare one partly reduces the transparency.

There is no dull varnish that would suit all types of pictures equally, but there are a number of different methods which can be chosen and adapted to each individual case.

Dulling Ingredients in Liquid Varnish.

126. — A quantity of commercial dull varnishes are available, some more or less successful, but on principle we cannot recommend any preparation the composition of which is unknown. Most of these compositions have the disadvantage of becoming brittle and very susceptible to scratching; moreover, they are difficult to apply evenly.

The most frequent and probably the best dulling ingredient is beeswax; the addition of a very small quantity to a varnish is sufficient to obtain a considerable degree of dulling. It is almost impossible to apply this kind of varnish without leaving any marks of the brush and the only satisfactory way is to spray it on by means of a spray-gun. (See the section above on the application of varnishes.) Another disadvantage is its slow drying quality.

Another possible ingredient is aluminium hydroxide or some similar neutral

transparent substance. This would, of course, be unsuitable for very dark and smooth paintings.

Deglazing of dry varnish layer.

127. — The simplest way of obtaining a slight dulling of a varnish is to let the layer dry thoroughly and then rub it with very soft cotton-wool. Another method especially suitable for paintings with a rough surface texture is to apply on top of the dry varnish layer another very thin layer, rubbing it in with a hard almost dry brush until the varnish gets sticky; the rubbing should be continued until the varnish is quite dry. Some skill is necessary to obtain an even finish in this way.

Another method consists in removing part of the dry varnish layer by means of different polishing or filing materials. The finest grain would probably be obtained by using polishing "rouge", such as is used for cleaning silverware, and subsequently polishing with soft cotton-wool. The success of the operation will, of course, depend very largely on the quality of the varnish itself. A stronger degree of dulling will be obtained by the so-called dry varnish removal method, that is to say by starting with a roughly pulverised grain of mastic or any other hard resin and filing off with slight pressure and rubbing, so reducing the upper layer of the varnish to powder. The very dull finish obtained by this method would suit only a few types of very light tempera paintings. It can be polished a little more with cotton-wool. A very agreeable semi-mat surface results when the varnish rubbed down in this way is subsequently polished with a soft silk-hat brush slightly wetted with wax paste.

Wax Dulling.

128. — This final application of a coating of wax also seems to be the most recommendable method to adopt for the treatment of any kind of shiny varnish (provided that it has not previously been submitted to one of the dry methods described above). It gives an agreeable semi-mat finish and can be polished to an even and practically completely transparent shine by means of soft cotton-wool.

To obtain a harder surface, the paste should always contain a little mastic or some hard mineral wax. The disadvantage of this finish is that it is more liable to get marked—finger-prints, etc.— but these can always be removed by renewed polishing with cotton-wool. Another drawback that should be men-

tioned is that some varnishes will dry more slowly and unevenly when applied over such a wax finish. As a rule, however. when the varnish is sprayed on it will dry satisfactorily. In some cases, it will be safer first to remove the wax finish with a swab of cotton-wool soaked in turpentine and wrapped in a piece of chamois leather. These latter disadvantages can be avoided by incorporating a little carnauba wax in the paste.

Dulling with the spray-gun.

128a. — The surface of a varnished picture can also be deglazed by the use of the spray-gun. The effect obtained is pleasing to the eye and, in many cases, the method is a very practical one. The screw which regulates the flow of the varnish may be so adjusted that only a small proportion of varnish is ejected from the nozzle with the air, leaving a thin haze of minute drops on the surface of the painting. The size of these drops and consequently the degree of dulling can be regulated according to the thickness of the varnish and the pressure used for spraying.

Sensitiveness of dulled varnishes.

129. — It should be borne in mind that all these processes which leave a somewhat rough and granular surface render paintings more sensitive to atmospheric influences, humidity, etc. This observation does not, of course, apply to a wax finish, which gives the most perfect surface protection so far known for paintings.

Wet method.

130. — Wet methods of dulling the varnish layer must obviously not be employed for paintings susceptible to damp. They consist in the application of a first thick coating of copal varnish; before this is thoroughly dry, a thick and even wash of aluminium hydrate or some similar substance is then applied. This is left to dry and then washed off with water; the surface thus obtained resembles that of frosted glass. A similar effect may be obtained by painting butter-milk over the dry varnish and removing it after drying. We mention these last two methods more to warn curators against them than to recommend their adoption.

CHAPITRE XIII

MALADIES AND TREATMENT OF THE PAINT LAYER

General Principles and Aims of Restoration.

131. — The stability of the paint layer which lies between the ground and the varnish is influenced not only by its own physical and chemical composition, but also by changes in the adjacent layers. If the ground cracks, the paint layer, in time, suffers likewise; if the varnish deteriorates, the paint layer is no longer protected and is liable to suffer. Damage which is not obvious may often be dangerous. On the other hand, a painting looks as if it were almost beyond repair, when, in fact, only the varnish has deteriorated.

To determine what is wrong with a picture and what can be done to restore it, some knowledge of the structure of the painting is required. It is not sufficient to adopt any sovereign method which would remove the disturbing symptoms without going to the root of the malady to be cured. For example, when a painting has become unsightly, dry and brittle, it may be greatly improved in appearance (''nourished'' or ''revived'') by rubbing it with some oily or greasy substance and many different patent materials are advertised for this purpose in the trade. But the improvement is transitory and there is more than a likelihood that further damage will accrue. If oil is used, the quantity absorbed by a dried-out picture is such that it might penetrate into the ground and alter the intended optical effect, making the picture darker in tone. Moreover, a drying oil would cause intensive yellowing in time and, when dry, would be impossible to remove. Non-drying oils (paraffin, etc.) would attract dust to the surface and alter the aspect of any varnish applied to it.

The object of this chapter, therefore, is to point out the danger of such injudicious methods of treatment and to endeavour to correlate various types of decay with their causes, and to outline methods of treatment which are of proven utility and efficacy.

No person who is not thoroughly initiated to the manipulation of such delicate substances as those which compose a painting should attempt to treat a picture. Even such a simple operation as wiping off the dust on the surface may prove disastrous; very often, the paint is ready to drop off in certain places and these

are liable to be torn off by the duster. None but an experienced eye is capable of foreseeing the danger in time.

However unimportant a painting may seem to be, it should never be entrusted to an unexperienced person for treatment, for it may well happen that a picture which has for many years been regarded as possessing but little value may, after cleaning, turn out to be a valuable work, the slightest deterioration of which would be irreparable. The following recommendations have therefore no other purpose than to give curators and owners of pictures, who are generally laymen in the technique and restoration of paintings, just sufficient insight into the various methods that will enable them to appreciate and understand the work of the expert restorer. (Those who wish to go deeper into the matter are referred to the bibliography given in the appendix.)

Restoration Documentation.

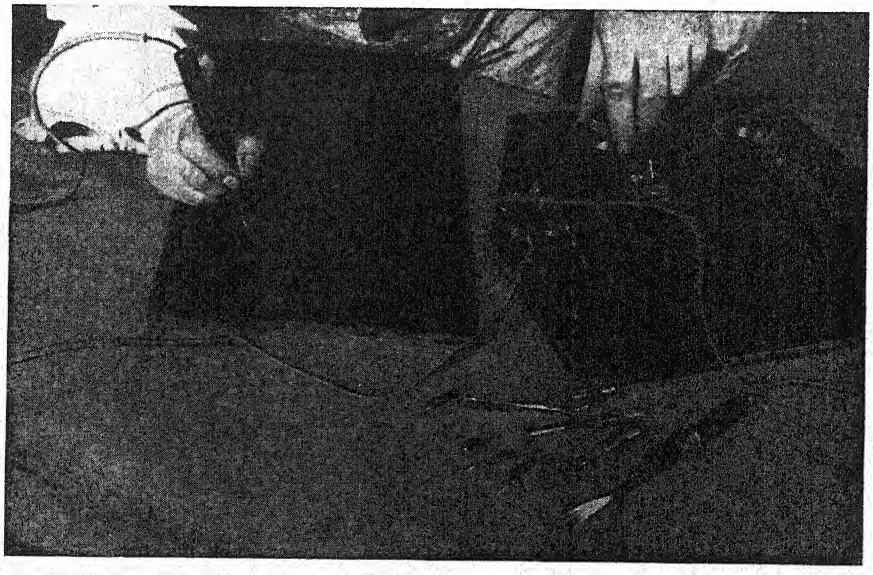
132. — Considerable progress would be realised in the conservation of present-day paintings if the artists could be prevailed upon to attach to their pictures a record of the materials which they have used and the methods adopted for the execution and varnishing of their paintings. Buyers of modern pictures should ask for this information or, indeed, make it a condition of purchase. This documentation would help to raise the standard of technique and to reduce the necessity of having to resort to treatment in the future.

The Restorer's Workshop.

133. — The artist-restorer should have at his disposal a well-equipped workshop, generously lighted by big windows and an uninterrupted ceiling-light; the equipment should, if possible, include an air-conditioning plant and the room should be protected against dust and draught, with facilities for raising the temperature to about 25° C. for varnishing. The wall-surfaces facing the easel, and the floor, should be painted in a dark tint, with a mat finish, to avoid the disturbing reflections thrown off by the picture under treatment. In one of the workshop walls there should be a window through which the rays of the sun can enter directly to facilitate the examination of dark pictures. With regard to the equipment and working tools properly so called, reference should be made to the chapter entitled *Methods of Investigation* in which the principal

instruments and devices that may be needed by a restorer are described.

None but the best quality of materials should be employed and, in general, one should under no circumstances use a preparation the exact composition of which is not known or which cannot be removed from the picture if necessary. The restorer should himself prepare his colours and varnish.



28. ELECTRICAL APPARATUS FOR THE TREATMENT OF BLISTERS. NEEDLES AND SPATULAS IN THE FOREGROUND.

A. — COMPOSITION OF THE PAINT LAYER

Definition.

134. — The paint layer may be defined as the film lying between the varnish and the ground. In the majority of cases, this film is itself composed of several superimposed layers: that on which the sketch is executed, the under modelling, one or two layers in grey or "local colour", and the final modelling. Each of these layers may, in turn, consist of several thin layers (only the modern "alla prima" paintings are executed directly in one single layer).

Paint is composed of two ingredients: the pigment and the binding medium (vehicle). Pigments are pulverised coloured particles. Media are colourless viscous liquids possessing drying or hardening properties. Their function is to bind the coloured particles together and to make them adhere to the ground.

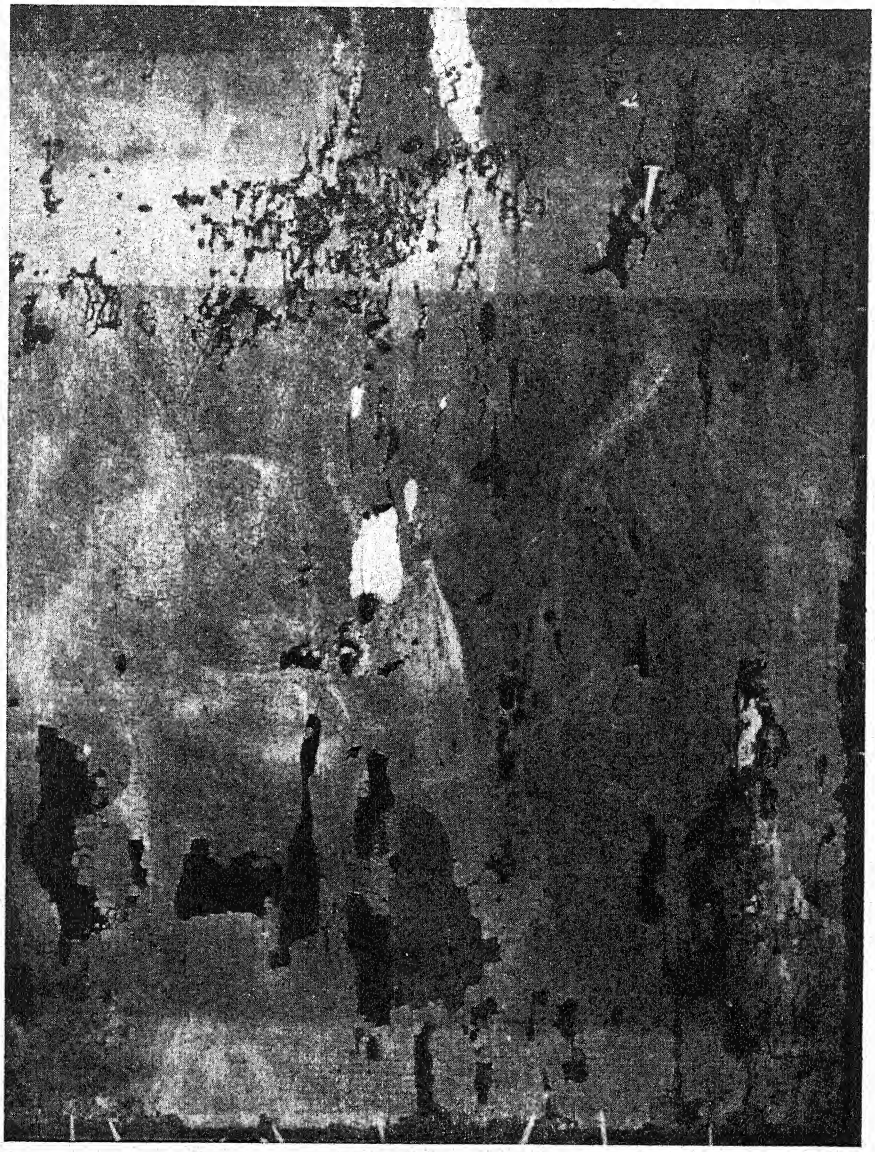
The stability of the paint layer depends on that of its constituents, and individual pigments and pigments alike show considerable variation in permanence under various circumstances; furthermore, when vehicles and pigments are mixed to form the paint layer, this combination can, in turn, show different kinds of decay.

The various painting methods, or "painting technique", are generally classified according to the nature of the binding medium used.

We give below a brief survey of the different types of media used for *easel paintings*, more particularly from the point of view of their respective stability and the different forms of decay to which they are subject. The *Table of Colours* given at the end of this manual contains a list of the principal colours used in painting, with an indication of the periods at which they are known to have been employed, together with data concerning their stability when combined with the various media. The present chapter concludes with a study of the paint layer as a whole, the mechanical forms of deterioration which are likely to occur, damage due to accident or improper treatment and, lastly, the different kinds of treatment that can be applied.

I. — Media.

Among the numerous materials which have been used in painting as binding media for the pigments, only a few can claim to be of any great permanence. Even that most widely used —linseed oil— is in no way stable from the strictly



29. RADIOGRAPH OF PART OF A XVITH CENTURY VENETIAN PAINTING; NOTE THE DIFFERENT SHADES OF COLOUR, BLACK HOLES AND WHITE AND GREY STOPPING, CORRESPONDING TO SUCCESSIVE RESTORATIONS.

scientific point of view; in practice, however, thousands of masterpieces executed with this material have survived after many centuries and are still in an excellent state of preservation. It frequently happens, of course, that the mixture of medium and pigment is more stable than the ingredients considered separately.

Aqueous Media.

135. — Media belonging to this class are soluble or become viscous in water; they dry rapidly owing to the evaporation of the water; they are insoluble in alcohol, volatile oils, etc. All of them are favourable to the development of mould in a warm, damp atmosphere.

Gum Arabic, the specific medium for water-colour, always remaining soluble in water, and white of egg, insoluble in water after hardening, are both used chiefly for miniatures, gouache, etc., and rarely for easel paintings.

Vegetable glues, such as starch, have been used from the times of antiquity to the present day.

Animal glue (size) and caseïn are also used for miniatures, etc., but play a great part not only in the *ground* but also in the lower layers of old pictures (drawing in, under modelling, etc.); they were also used in a great number of early easel paintings of a special type, executed on canvas or wood entirely with glue paint, —a technique known from the earliest times. This medium loses its adhesive power in a warm, damp atmosphere and then becomes soluble in water, hence the danger of applying water to pictures so executed. Disintegration caused by damp or mildew, etc. can, however, often be arrested by drying and by simultaneous disinfection, also by tanning, or hardening (treatment with formalin vapour).

Size paints are generally referred to as "distemper", and wrongly as "tempera".

Tempera Media.

136. — The word *tempera* comes from the Latin TEMPERARE (to mix), but it is now used to designate a medium composed of a natural or artificial emulsion, that is a well malaxed colloid containing aqueous and oily constituents.

The prototype of an emulsion is *egg*, and up to the XVIth century the white and the yolk, or the yolk alone, formed the predominant paint medium. From that date onwards, oil was more and more widely introduced, but egg media

continued to be used, probably until the XVIIIth century. They were more commonly used for panel paintings, but occasionally also for suitably prepared canvas paintings. Nowadays, they are employed more for the under-painting than for the complete execution of easel pictures.

Egg can be mixed with oils and resins and all sorts of combinations are possible and may have been adopted in earlier times.

Fig milk, which is really an adhesive, may also be used as an emulsion. Most of the combinations and artificial emulsions, such as gum-oil and glue-oil did not come into current use until towards the end of the XIXth century.

Emulsions can be diluted with water. They harden or dry by evaporation of the water, but also by a sort of hardening or gelation, and by oxidation.

Generally, egg emulsions and some of the other combinations are no longer soluble in water once they have hardened. They naturally assume some of the properties of the ingredients incorporated in the mixture.

Egg has always been, and continues to be, the most lasting of the known media for easel paintings. Under normal conditions, it does not darken (like oil) and offers a better resistance to atmospheric influences and to most of the cleaning solvents.

The reason why tempera paint has gradually been abandoned is probably that it is not so easy to handle as oil paint and does not lend itself so well to naturalistic representation.

Oil Media.

137. — Oil media are composed of the various drying oils, such as linseed oil, poppy oil, walnut oil, etc., in their natural (purified) state or thickened by exposure to the sun or by boiling. These oils were known to the painters of antiquity but it is supposed that they were not generally used as media until the XVIth century.

Oil paint gives a more shiny and more transparent effect than size or tempera paint. It dries or hardens by oxidation, much more slowly than paintings executed with aqueous media or with emulsions; drying is sometimes accelerated when the oil is mixed with certain pigments. This explains the unequal cracking sometimes to be seen in the same picture. Complete hardening may take several years, but, once hardened, oil paint is soluble only in a very strong solvent. It is remarkably elastic but tends to become brittle with age, if exposed to light and air. It can be diluted by the addition of volatile oils or essences, such as turpentine or copaiba balsam.

All oils darken more or less, especially in poor light. This phenomenon is generally partly reversible, that is to say the paint will gradually resume its original tone if exposed to strong daylight.

Some old paintings have darkened remarkably little; this may perhaps be explained by the fact that the artist used some special preparation, such as stand oil, which seems to darken considerably less than other oils.

The bad state of preservation of so many oil paintings of the XIXth and XXth centuries is due partly to the inferior quality of the paint manufactured commercially (as compared with the paint prepared by hand under the eyes of the master in the old workshops), and partly, but in a larger measure, to the negligent manner in which it was handled and applied to the support.

It was also in the XIXth century that pernicious drying ingredients were introduced, either in the manufacture of the paint or in the preparation of the solvents and varnishes that were added to keep the paint liquid and sufficiently workable for several days. These ingredients are conducive to blackening, cracking and wrinkling.

Wrinkling, a phenomenon similar to the wrinkles formed at the finger-joints on the back of an outstretched hand, is to be found on many paintings by Watteau; it is largely due to an excess of oil in the paint. Very often, the wrinkling to be seen on earlier pictures indicates an over-painted area (Fig. 30).

In the process of oxidation, oils develop acids, which, in many cases, have deteriorated the canvas through the lack of an intermediate protective layer of sizing (see the chapter on the *Ground*).

With the exception of the yellowing caused by oil and referred to above, all these changes are nearly always irreversible. (See the section below on *Crackle.*)

Resinous Media.

138. — Resinous media, which are more or less the same as the resins used for varnishes, have rarely been employed for paint media unless combined with oil or wax. From the XVIIIth century onwards, they were often added to oil paint, especially for pictures of the English school. A large number of resinous media were known to early painters.

From the point of view of their optical effect, they are similar to oil media, but become brittle much sooner and are more susceptible to atmospheric influences; they always remain soluble, even in weak solvents such as turpentine or petrol. (See *Cleaning*, Chapter XII.) For this reason, many paintings

executed with a medium that contains resin have suffered very seriously from over-cleaning.

On the other hand, when dry and crackled, these pictures lend themselves better to regeneration (see the chapter on the *Varnish Layer*) than paintings executed with a pure oil medium.

The resins used in paintings are:

a) *Hard resins*, mostly only soluble in hot oils; they are all more or less dark in solution and probably darken still more in the picture. (See Chapter XII: *Varnish, copal, amber*, etc.)

b) *Soft resins :* soluble in weak solvents such as turpentine; they darken much less than hard resins (mastic and dammar) and oils.

c) *Balsams:* these are slow-drying or non-drying substances and are not to be recommended as paint ingredients; they were occasionally used in the XIXth century (larch turpentine, copaiba, Canada balsam).

The modern *artificial resins* or cellulose media have so far been but little used and will not be described in detail here.

Wax Media.

139. — This category of media includes: beeswax, paraffin or mineral waxes; when used as media they are liquefied by warming to about 50° C. —encaustic (old Egyptian technique)— or combined with resins (in which case they are diluted with essential oils —wax paint, or converted into an emulsion by saponification (addition of alkali in water).

As regards their optical effect, these media come between the tempera media (emulsions) and the oil media. Unless they are polished, they give a mat surface; they are not completely transparent.

As proved by the state of preservation of the portraits painted on Egyptian mummy cases, these media are remarkably stable; they are inert, offer more resistance to moisture and other atmospheric influences (sulphur dioxide, etc.), are fairly elastic and do not darken. They are always easily soluble in weak solvents, such as benzine, turpentine, etc. They become brittle in severe cold. this may be remedied by careful warming and subsequent polishing.

(See also : *Retouching, Relining, Varnish.*)

Bloom.

140. — Paintings executed with resin or wax media are subject to *blooming*; This phenomeon, which is caused by atmospheric influences, takes the form of a whitish, opalescent haze that spreads over the surface and is especially visible on the darker areas of the painting (see also Chapter XII). It can be remedied by dry polishing, in gentle warmth, with cotton-wool, or, in the case of wax paint (which would have a tendency to become sticky), with a very soft silk-hat brush.

Optical Function of Media.

141. — Although the groups of media described above differ considerably in character, it is often impossible to ascertain, by mere inspection, which has been used in a picture (oil or tempera paint, for example). There are several reasons why it is impossible to identify them:

a) The painting (especially in old masterpieces) is often built up of different layers executed with different media; e.g. size or tempera for the lower layers, oil for the upper layers.

b) More or less complex blends of the different media may have been used, particularly emulsions combining the optical properties of oils and tempera; or, again, the artist may have used unknown preparations and incorporated them in the commercial tube colours adopted for modern paintings.

c) Even in one and the same layer, different pigments may have been ground with different media, for some pigments are more stable when combined with certain media; for example, verdigris between two layers of varnish.

d) The initial aspect of a paint is often altered by impregnation with, or the application of, an oily varnish.

The permanence of a medium undoubtedly depends very largely on the appropriate choice of the raw material, on its treatment during the manufacture of the paint and on its judicious application during the execution of the picture.

II. — Pigments

142. — The striking brilliance of certain old masterpieces has given rise to the idea that brilliant pigments were available in the past but are no longer

available today. This is not the case; on the contrary, today we have a much wider range of pigments than ever before and some of them are even of greater permanence. Some of the pigments used by the old masters have since become obsolete because of their instability; on the other hand, there are some which are no longer used but which are remarkably stable. Old paintings owe their brilliant appearance less to the actual materials used than to the conscientious manner in which they were prepared and applied and to the skilful exploitation of their optical properties (transparency, contrast effects, etc.). Furthermore, the brilliance of certain pigments is today attenuated by the excessive grinding to which they are subjected in modern mechanical processes of manufacture. In the XIXth century, several new colours were invented and all were too hastily adopted by painters. Several of them have since proved to be impermanent.

Today, pigments are subjected to severe scientific tests and selection before they reach the artist's palette and, for this reason, a greater number of reliable colours is now available than at any time in the past, so that no painter need now be obliged to resort to pigments of doubtful stability.

Stability of Pigments.

143. — The range of pigments used in the different processes of painting from the earliest times is so extensive that it would be impossible to deal exhaustively with all of them here. The *Table of Colours* at the end of this manual gives details for the principal colours which, for the purposes of this study, are of special interest because of their stability under certain conditions, their reaction to cleaning, etc.

Unfortunately, very few of the changes which take place in the paint layer on account of instability can be reversed.

It is often difficult to judge to what extent a pigment has bleached, darkened, or changed in colour. Information on this point may sometimes be gained when, for instance, part of the required colour has been protected from fading by the frame. Often also some high lights strike the onlooker as too chalky or discordant; this may be accounted for by the bleaching or fading of the light parts or glazes. Old masters very often underpainted coloured garments in grey (or some other tint) with white high lights. On the other hand, the contrasts of light and shade have become emphasised with time; this may be due to the darkening of colours (browns, etc.) or to the fact that a dark priming or under-

paint has pierced the upper layers (Ribéra); this latter phenomenon may be caused by an increase in the translucency of pigments where oil paint is present, or by wearing or abrasion of the upper lighter layers. Instances of such showing through of the red bolus priming are common in the works of Goya and Tintoretto. (See: *Ground.*)

B. — CHANGES IN THE PAINT LAYER

I. — Changes due to the structure of the paint layer

Complex Structure of the Paint layer.

144. — In the majority of cases, the paint layer is built up of a series of independent layers: the drawing-in layer, one or two lower layers in grey or "local colour" and the layer in which the final modelling is executed. Each of these layers may be composed of several thin superimposed layers. (Only modern "alla prima" paintings are executed directly in a single layer.) Among the exceptions to this general rule to be found in the past, we may mention the wax paintings of the Egyptians, the works of Franz Hals, etc.

Each of the principal layers mentioned above can be executed with a different medium: the preliminary sketch or drawing-in, with a little ink, for example; the first modelling (monochrome) with size; the lower layer with egg, or even all the lower layers with size or tempera, and the final layer with oil.

Ageing.

145. — As has already been pointed out, many of the changes which occur in the paint layer itself can be traced to imperfect technique. Most of them can be revealed by an analysis of the media and pigments (see Chapter II). But even the most judicious technique and the best conditions of exhibition or storage cannot preserve a painting from some kind of natural ageing. Beyond a certain point, natural ageing leads to deterioration and, finally, to maladies which cannot be entirely avoided, but which can be delayed or appreciably attenuated by certain treatments.

A more thorough tuition in sound technique, based on a knowledge of the methods of the old masters, will in future help to avoid the decay which is so manifest in paintings of the late XIXth century.

We have to distinguish between two main kinds of changes: those which take place in the process of drying or hardening, and those which occur when the paint is dry.

Crackle.

146. — The most frequent impairment is *cracking*. The majority of old pictures show lines or a network of finer or coarser cracks. Their structure, pattern, etc. are often characteristic of certain schools and periods. The possible causes are so numerous that they will perhaps never be exhaustively explained. Systematic investigations have been in progress for some time (see *Bibliography*) and it is desirable that an exchange of observations should be arranged on this essential point arising in connection with the deterioration of paintings (see Fig. 33).

Cracking which occurs during the drying process has been described as *early cracking*. It is due chiefly to some imperfect technique and may occur independently in any of the layers enumerated above; it does not affect the ground and has no relation with the structure of the support, but often with the direction of the brush-stroke. It appears in a variety of forms, in many cases even in the same picture, because different pigments (colours) may contain very different amounts of the same medium or even different media, with the result that these materials are subjected to different degrees of tension during the process of drying.

Some colours (pigment plus medium) have themselves a tendency to crack, for example: the more transparent colours, particularly the lakes, lamp-black and ivory-black.

The question of *recent crackling* will be dealt with in the section "Changes due to the support", for, in the majority of cases, it is due to movements of the support.

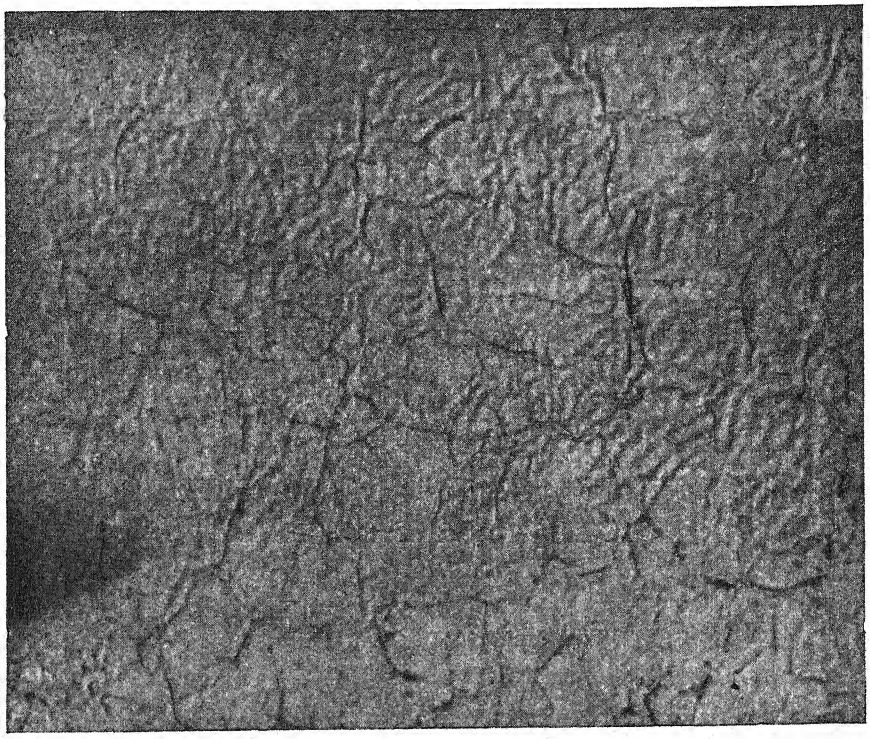
Treatment.

147. — As a rule, crackle is to be regarded as a natural feature of old paintings, as it generally does not very much impair their general appearance, no steps should be taken to "restore" them.

Only in extreme cases, mostly due to the use of *bitumen*, especially in the XVIIIth and XIXth centuries, where they become too disturbing, may the cracks be filled in with paint. (See: *Retouching*, §§ 170-172.)

Crackle can very seldom be reversed, and then only in mild cases, especially when resins are present in the medium, by a process of *regeneration*. (See § 112.)

Early crackle, which has occurred during the drying process, will rarely grow worse with time, although the cracks caused by the movement of the



30. PORTION OF A WATTEAU. EXAMPLE OF PAINT CONTAINING AN EXCESS OF OIL. THE FILM HAS WRINKLED IN THE PROCESS OF DRYING.

support will attack the paint layer at its weakest points — for example, by widening some of the early crackles already existing. (Figs 33-39 and 53.)

Blisters.

148. — Cleavage, flaking and blistering are, in most cases, caused by the support or ground; sometimes, however, they are due to insufficient adhesion between the different coatings of the paint layer. This occurs, for instances, when watercolour (gum) is applied to a coating of oil paint, or if some greasy impurity existed on a layer when the next one was applied.

For the treatment of blistering, see Chapter XIV, §§ 179-181, on the treatment of deteriorations in the paint layer.

Changes due to the support and ground

149. — It stands to reason that any movement or strain in the panel or canvas will tax the elasticity of the ground and of the paint layer, and give rise to various impairments. (On this point, see Chapters XIV and XV, §§ 176-191, 230-232.)

Cracks in the panel are communicated to the ground and paint, and this may flake off along the edge of the gaps.

Repeated warping—or skrinking and expansion in the case of canvas—is a frequent cause of cleavage and blistering of the ground or of the paint; very often, this will occur in both ground and paint layer.

Reflected light will reveal any unevenness of surface. In any case, the symptoms—the blisters—must be treated so that they may be made to adhere to the ground.

Blisters.

150. — Large blisters (loosening of the ground and paint layer from the support in the form of lumps or blisters) are the principal deterioration likely to occur in the paint layer and the most frequent cause for restoration.

They occur just as commonly in panel pictures as on canvas, especially in Italian paintings executed on soft wood (poplar). When the ground or the paint is not sufficiently elastic to follow the inevitable movements of the wood or canvas, this suffices to produce blistering.

The graver cases are generally due to deterioration of the wood, of the ground independently of the support, or of both (see the relevant chapters), or to an abnormal shrinkage of a panel, the latter becoming so narrow as to leave insufficient room for the paint layer, which is compressed towards the centre. This may be caused by abnormal surrounding conditions (see *Surroundings*) or by bad quality or, in some cases, by disease in the wood (see *Parasites*).

Prevention.

See Chapter III. — *Surroundings.*

31. METHOD OF FIXING A LOOSE PAINT LAYER. THE BLACK PATCH IS A WORM-HOLE.

Treatment. (See also §§ 180 and 181.)

151. — When a complete relining or transfer is unnecessary and a local treatment of the affected areas is sufficient (the symptoms being caused by accidental influences only), the following method is adopted:

When a picture shows areas where the paint layer is loose, these must first

be secured by sticking transparent Japan paper or adhesive tape over them (see *Relining*). Wax, paste or rubber may be used as adhesives,—in general, any adhesive that can easily be removed by weak solvents which do not attack the varnish, e.g. benzine; care must be taken, however, not to use size, as this hardens to excess during the process of drying and is apt to detach the varnish or the loose parts of the paint layer. If size or gelatine be used, these substances must be well diluted and rendered more soluble by the addition of a small quantity of glycerine.

A stronger adhesive should then be introduced beneath the loose areas. In the case of a canvas support, this may often be done from behind, sometimes by pricking the canvas in the areas corresponding to the loose parts of the paint.

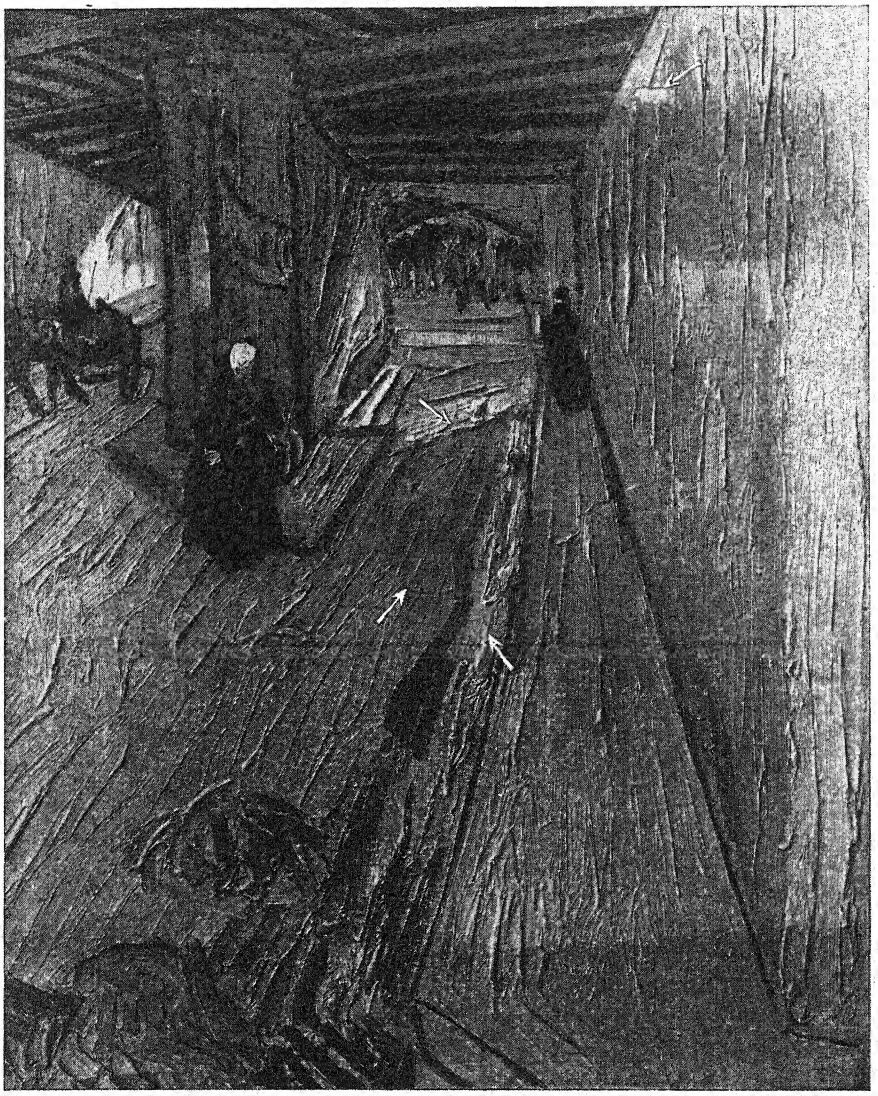
When the affected areas have been covered with paper, etc., the raised portions should be pricked, preferably on the already open cracks, by means of a fine needle electrically heated to a temperature sufficient to penetrate the paint layer slowly, without scorching or burning it. (A cold needle breaks the paint and makes too big holes. See Fig. 28).

When the blisters have not been covered with paper, or when the cracks are sufficiently wide to permit of introducting the adhesive liquid, no pricking is needed.

The needle should be inserted obliquely rather than perpendicularly, in order to facilitate the penetration of the adhesive. Two or three tiny perforations will suffice, even for the treatment of a big blister, when the needle is nserted at the crest. (See §§ 197-207.)

152.

An emulsion of wax and Venetian turpentine, mixed with gelatine, may also be used. This mixture has the advantage of being more strongly adhesive and, provided that the emulsion is white, of modifying the refractive power of the ground less than a mixture of resin and wax. It can be thinned by adding spirits of paraffin oil. (See: *Treatment of Wood.*) These considerations are important for all pictures where the white reflecting ground plays a part. The relative proportion of the substances which go to make up the emulsion depends very largely on their individual properties and on the temperature; a trial should therefore be made before each application.



32. VAN GOGH: " THE SUBWAY ". — THE WHITE ARROWS INDICATE THE PARTS WHERE PARTICLES OF PAINT HAVE BECOME DETACHED, LOOSENED PERHAPS IN THE COURSE OF CARELESS CLEANING. THE LOOSE PARTICLES MUST BE FIXED BY RE-LINING. HEAVY IMPASTATION NECESSITATING A SPECIAL BED DURING THE RE-LINING OPERATION. DARK GREY BANDS ABOVE AND BELOW WHERE SUPERFICIAL DIRT HAS NOT BEEN REMOVED AND SHOWING A NOTABLE DISFIGUREMENT, DUE SIMPLY TO DUST, ETC.

This emulsion is also very suitable for relining, where a specially strong adhesion is needed (for energetic cleaning, for example). Glue without the addition of a plasticiser (resin, wax, etc.) is to be avoided. (See § 205.)

Application.

153. — When the parts to be treated have been gently warmed, the adhesive is introduced, through the cracks or perforations, in a hot liquid state by means of a small electrically heated spatula, the heat being carefully regulated not to exceed 70° C. by a resistance according to the sensitivity of the paint.

With gentle pressure and moderate heat, the adhesive will soak in and the loosened areas can then be pressed down and levelled with the same spatula slightly cooled.

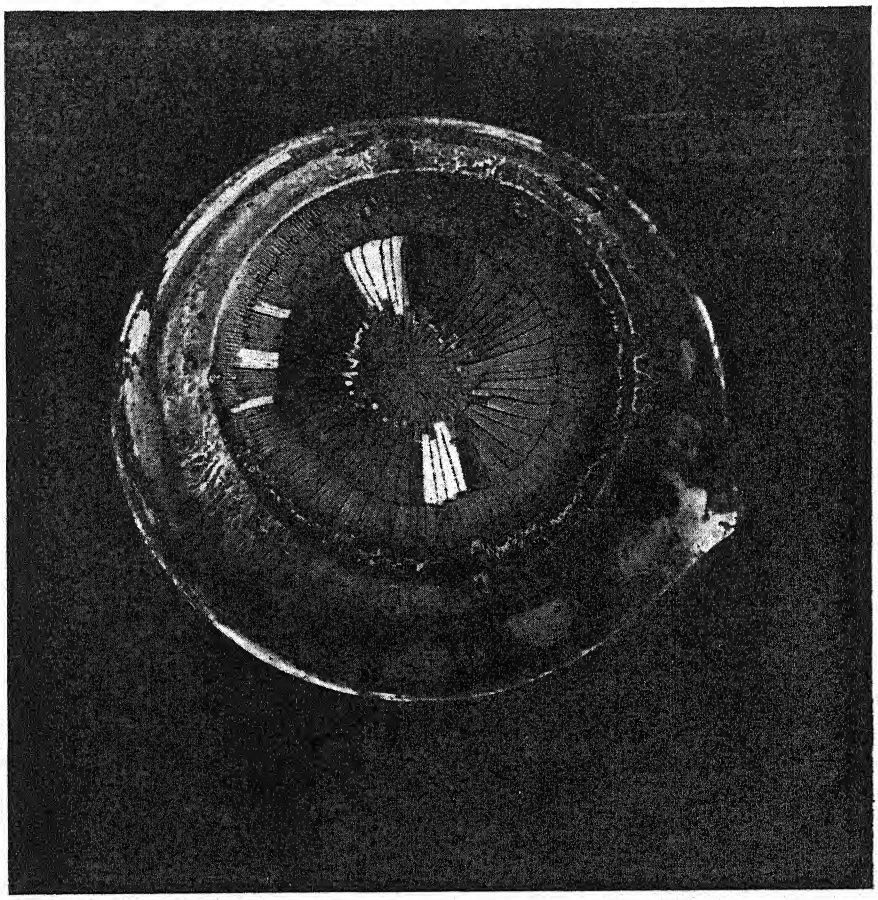
If this operation is skilfully carried out, no fragment of paint will be lost, even if no paper or other protective covering has been applied.

When the adhesive is dry, the protective covering is washed off. If necessary, the blister can again be levelled down with the heated spatula, pressure being brought to bear directly on the unprotected surface.

Raising method.

154. — When there is a considerable hollow under the paint layer (wormholes in the wooden support, for example), the loose particles of paint can be raised by means of a strip of transparent adhesive tape, part of which remains stuck to the firm part of the paint; the tape is thus manipulated like a hinge. The hollow can be filled with putty, etc., and the paint particles stuck back exactly in position in the way described above (Fig. 31).

In the case of a wood panel-painting and provided that the paint layer is in a good state of preservation, a disquieting hollow can be remedied by operating from the back. First of all, the paint layer should be secured by means of a strip of transparent adhesive tape covering slightly more than the area of the cavity. The panel is then screwed, face downwards, to a smooth, hard board; a square corresponding in size to that of the cavity is next cut out of the back of the panel and pressure brought to bear on the ground and paint layer until they are level with the remainder of the panel. When this stage of the operation is terminated, the space left between the ground and the panel is filled first with a liquid adhesive and then with mastic.



33. EXAMPLE OF VARIOUS FORMS OF ACCIDENTAL CRACKLES IN A TEMPERA PAINT LAYER APPLIED TO A SMALL PLATE, SHOWING HOW THE SHAPE OF THE SUPPORT AND SLIGHT DIFFERENCES IN THICKNESS AFFECT THE FORM OF THE CRACKLES.

When the strong adhesive is thoroughly dry, the paint layer will adhere more firmly to the support and ground than to the adhesive tape, and this can be carefully raised and any portions of the tape which remain stuck to the picture may be washed off. The type of tape used should have a rubber adhesive as this can be removed by a solvent (benzine) and does not attack the varnish.

Precautions.

155. — It frequently happens that a particle of paint detaches itself from the ground, which, in turn, becomes separated from the support; if it is found that a particle of paint has stuck to the adhesive tape (which has not yet been completely removed), this particle must be stuck down before the tape is completely withdrawn.

Thin strips of glass may be stuck on to the tape to prevent crackling during the process of lifting.

The adhesive power of the tape should be just sufficient to tear off any particle of paint that does not stick firmly enough to the ground.

Recurrent deterioration.

156. — If, after such treatment, further blistering occurs, or if the blisters are caused by some chronic disease of the support or ground, more radical methods will have to be adopted. (See: *Transfer, Re-lining*, etc., §§ 182-224.)

Crackle, a form of deterioration which is regarded as a natural phenomenon, will generally not develop further in pictures more than about fifty years old, for it will then have attained its maximum. The pictures will therefore be affected only to an insignificant extent by atmospheric conditions, unless they are exposed to a radical change of climate.

For exceptional cases due to the faulty adjustment of the framing of a panel or canvas stretcher, see the sections dealing with supports (§§ 229-250).

Deterioration due to resin in the support.

157. — In certain paintings executed on a thin ground, such as some Dutch XVIIth pictures, the resin in the grain of the wood often penetrates the ground and stains it, as well as part of the painting, a dark brown. Streaks then make their appearance through the paint.

34. DETAIL OF A MEMLING: NORMAL CRACKLES TYPICAL OF XVTH CENTURY GERMAN PAINTINGS PROBABLY DUE TO THE TRACTION EXERTED BY THE PANEL ON THE PRIMING AND PAINT LAYERS.

A similar brown stain that seems to come from beneath is sometimes found around the crackles in thicker grounds.

When these stains become too disturbing, they should be covered with a fairly dense coating of tempera paint.

III. — Deterioration due to the varnish layer

Chapter XII, *Maladies and Treatment of the Varnish Layer*, gave the necessary details concerning the function of varnishes, their composition, the deterioration to which they are subject and the treatments that can be applied. Certain points dealt with in that chapter will be taken up again in the following section, in order to define the part played by the protective layers in the deterioration of the paint layer.

Mechanical or aesthetic function of varnishes.

158. — Generally speaking, few cases of real damage to the paint layer can be attributed to the varnish, although optical conditions—appearance of the paint layer—are largely dependent on this protective coating. Moreover, many cases of deterioration which seem to have spread to the paint layer are completely localised in the varnish layer.

On the other hand, a varnish applied to paint that has not thoroughly dried may cause deterioration—blooming and darkening, for example—because the necessary process of oxidation of oil paint is impeded by the film which prevents it from coming directly into contact with the air.

It should also be pointed out that a varnish which has partly or completely disintegrated becomes permeable and its protective properties are thus reduced or destroyed; the paint layer is henceforth exposed to the pernicious action of the atmosphere.

Further, yellowing—the most frequent form of deterioration that occurs in varnish—causes no material damage to the condition of a painting; it merely mars the effect intended by the artist.

Some forms of mechanical deterioration may be attributed to the varnish: the latter shrinks in the process of drying, and, since it adheres to the paint layer beneath, it sometimes tears this layer if it is particularly fragile. This rarely occurs in old paintings. Only a picture executed with a resin medium and softened by regeneration, for example, will suffer from deterioration of this

35. DETAIL OF A TERBORCH. CRACKLES CHARACTERISTIC OF XVIITH CENTURY DUTCH PAINTINGS, PROBABLY CAUSED BY THE NATURAL TRACTION OF THE CANVAS WITH AGE.

kind if, before it has recovered its firmness, a hard quick-drying varnish is applied immediately.

In the case of recent paintings (and retouching executed with oil paint), this danger is by no means negligible. The contraction of the varnish as it dries may very easily tear the paint layer and cause serious crackling. Fakers take advantage of this phenomenon to produce artificial crackles in their paintings.

This danger can be very appreciably reduced by applying only a thin coating of a varnish which is sufficiently elastic (mastic or dammar dissolved in turpentine, to which a small quantity of stand oil has been added), in accordance with the recommendations set forth in Chapter XII.

IV. — Deterioration due to acccidental causes or previous interference

Cases warranting restoration.

159. — The treatment of the forms of deterioration so far dealt with may be classed under the heading: *conservation measures.* We shall now examine the cases where there is real loss (or obliteration) of a painting and where the only remedy lies in *measures of restoration* properly so called.

The first reason which generally urges one to resort to measures of restoration is the discovery of some deterioration of this kind or some change in the varnish which affects the appearance of the picture.

Preliminary Examination.

160. — To reduce disappointment to a minimum and to give the owner or curator, as well as the restorer, every possible guarantee, any work of value should be subjected to a very thorough examination (preferably in the presence of the owner or curator, or a witness) and all the observations photographically recorded, recourse being had to all the processes offered by modern technique. This inspection should precede restoration. The ideal method of recording the results of such an examination would be to take large stereoscopic photographs in colour, completed by macrophotographs of the most important details. (See Fig. 25 and §§ 8-25.)

36. CRANACH: " LUCRETIA " (DETAIL, APPROXIMATELY × 2 ENLARGEMENT); FORM OF CRACKLE CHARACTERISTIC OF CRANACHS, PROBABLY DUE TO THE TRACTION OF THE PANEL ON THE PRIMING AND A PAINT COMPOSITION PECULIAR TO THE MASTER.

The question of cleaning.

161. — Once all the minor repairs have been carried out and the varnish regenerated, the question frequently arises whether it would not be advisable to remove the dark varnish which disfigures a picture, so that the painting may be seen to its best advantage.

Nobody but the restorer can decide whether such an improvement is compatible with the estimated amount of work involved; it will then be for the owner or curator to decide whether the expense incurred is in keeping with the value of the picture.

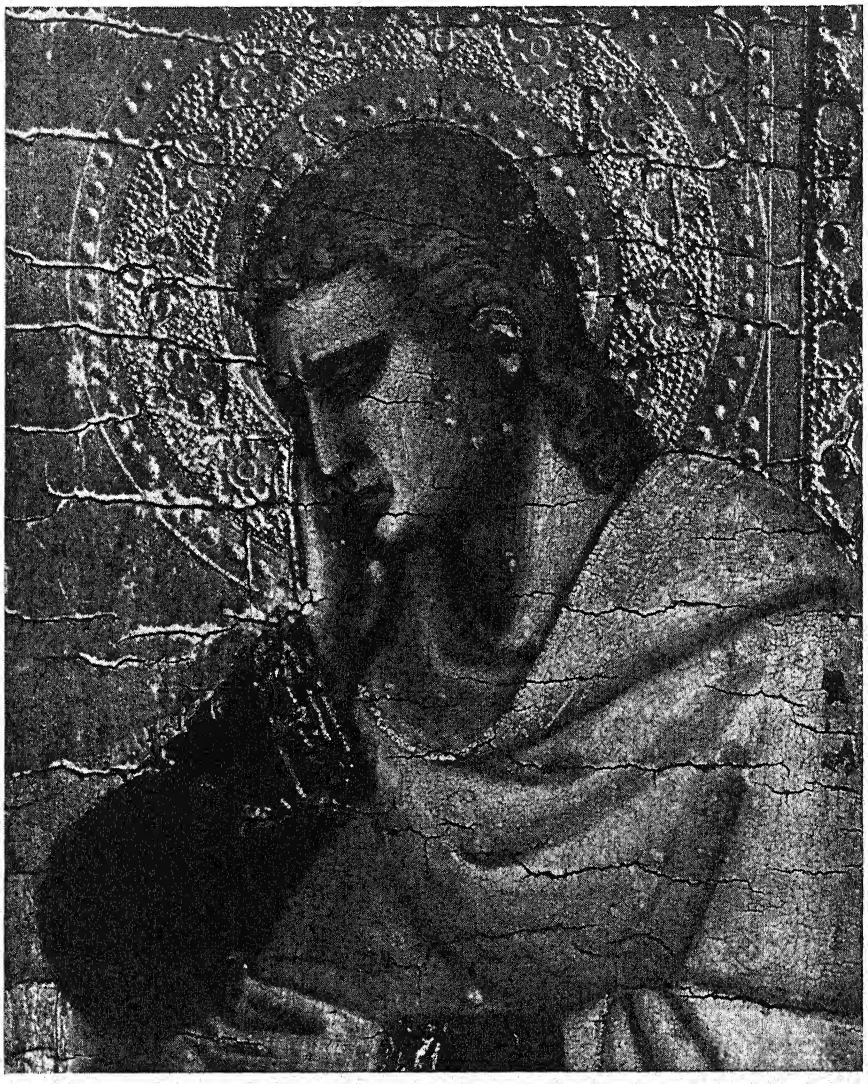
Since it is extremely rare to see an old picture which has not been restored in one way or another, it frequently happens that retouchings appear and may also be removed with the varnish; in the majority of cases, these retouchings will have to be done over again.

However experienced a restorer may be, he will not always discover all the retouchings through an old semi-opaque, dark and crackled varnish,—not even by ultra-violet rays.

Lighting.

162. — We wish to emphasise once again that strong light—sunlight, which is always the most favourable, or a powerful source of artificial lighting with "daylight" bulbs— will always prove to be more useful than strong magnifiers or a complicated apparatus. A good full-size photograph or a photograph taken with direct magnification of about $\times 3$ diameters (indirect enlargements are never sufficiently clear) will often show all that one wishes to know about the condition of a painting.

Either before or after the removal of the varnish, many old retouchings, executed with oil paint which has darkened with time, are visible to the unaided eye in the form of dark patches. In good light, a lens of about $\times 6$ to 8 diameters will, in most cases, show whether the crackle in the original is covered or concealed by a superimposed layer, or whether it has been artificially produced in the repainted areas. Even the most skilfully executed artificial crackle will differ, in one way or another, from original crackle. One must, however, be very cautious before drawing conclusions; there may be paradoxical cases where artificial crackling is found in the original paint layer, or natural crackling in the parts repainted, because, in time, a natural crackle will often spread to the ayer above. (See Fig. 28).



37. DETAIL OF A PAINTING BY ORCAGNA, SHOWING CRACKLES CHARACTERISTIC OF THE XIVTH CENTURY, EXAMPLE OF STABLE CRACKLES WHICH NEED NEITHER TREATMENT NOR RETOUCHING. THE FINE NETWORK OF CRACKLES, PARTICULARLY ON THE FACE AND GARMENT, PROBABLY DEVELOPED AS THE PAINT LAYER DRIED.

Very often also, a difference in *texture* (of the paint layer) reveals the areas which have been clumsily or injudiciously treated; these areas are especially conspicuous when examined under reflected or oblique lighting (see Chapter II, §§ 8-25: *Methods of Investigation applied to the Examination of Pictures*).

For magnifications of more than ×8 diameters, binocular magnifiers should be used so as to obtain a stereoscopic view of the picture; special lighting such as is used for microscopical examinations should be available, with a tinted filter—natural lighting. By this means, it is possible to see the differences in structure and, very often, with a magnification of from ×30 to 100 diameters, the different grains of the pigments in the original as well as in the parts repainted.

Polarised light (see Chapter II, § 21) is very useful for examinations of this sort.

Ultra-violet and infra-red rays. — An examination or a photograph by ultra-violet or infra-red rays will, in many cases, show up retouchings, which will appear as dark (or light) clearly-outlined patches, unless the rays are stopped by certain oil varnishes or a varnish that has disintegrated.

All these methods of examination will more or less clearly reveal the extent of the areas repainted, but will not show the real deterioration covered by these additions.

X-Rays. — An x-ray photograph (radiograph) or a radioscopic examination will generally show that the actual gaps are of an infinitely smaller area than the retouchings; formerly, retouchings were not executed with that scrupulous care to be noted today, and very often they spread over a considerable portion of the original adjoining the deteriorated area.

Here again, the utmost caution is necessary in drawing conclusions from a radiograph or radioscopic examination, for, very often, x-rays do not reveal the actual hole but the stopping, and—as in the case of certain retouchings—the mastic extends well beyond the deteriorated area.

It occasionally happens, therefore, that one discovers fairly large areas of the original paint in a good state of preservation, not only under the retouchings but also under the mastic. Very often, after having removed the overpaint, a perfectly well preserved paint is found. The coating which sometimes extends over the entire picture was obviously added with the intention of "improving" its aspect as a whole. Even up to recent years, notable changes were frequently made in garments in accordance with current fashion or the prevailing ideas as to propriety.

C. — TREATMENT AND RESTORATION

Trial Cleaning.

163. — When there is no possibility of taking photographs or of resorting to other methods of recording, either because such measures would not be justified by the value of the painting, or because of the expense involved, an approximate idea of the state of preservation of a picture can be obtained by carrying out, in the presence of the owner or curator, two or three trial cleanings on very small areas, in the parts where it is presumed that the original paint has been covered by additions. The cleaning is done with a small pointed stick wrapped in cotton-wool moistened with a solvent.

The methods of *removing varnish* were described in Chapter XII. No varnish should be removed until all loose particles of paint have been secured by local treatment or by re-lining. The wax adhesives described in the present chapter will perhaps not be strong enough. If it is expected that the cleaning will require the use of active solvents, more strongly adhesive emulsions must be used.

Removal of Repaint.

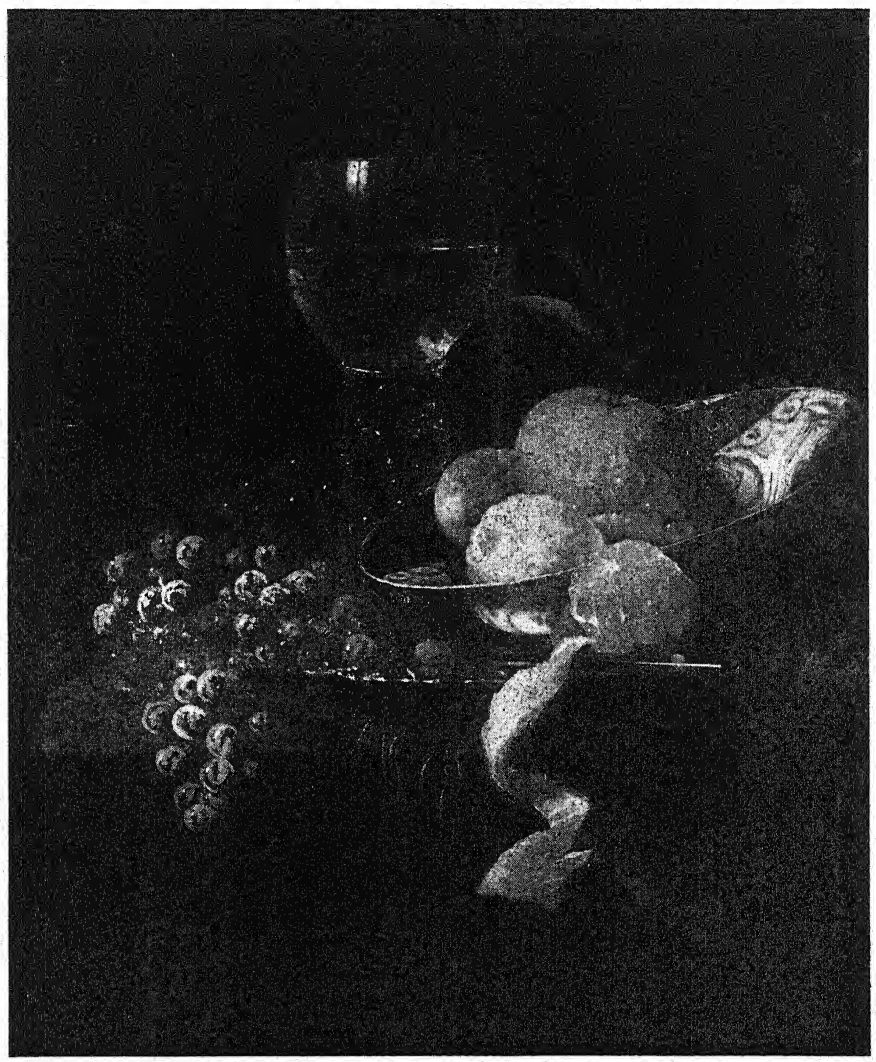
164. — Repaint and retouches recently executed with a resin medium will also disappear with the same more or less mild solvents that dissolve the varnish.

In many cases, however, recent retouches, when executed with aqueous media—water-colour or tempera—will not yield even to the stronger varnish solvents. The same holds good when an aqueous isolating coating is laid on the retouches. They will, however, sometimes dissolve with cold or warm water; for this operation, the cotton-wool swab should never be soaked, but only just damp.

Some tempera retouches and old oil retouches will only give way to stronger solvents.

As a rule, retouches are softer than the older original paint and they can therefore be dissolved without risk of damaging the older layer. Thus, the widespread opinion that cleaning is always dangerous for all types of pictures is fortunately proved to be incorrect. It is perfectly true that cleaning is attended by certain risks, but only for a small category of paintings executed with media that remain easily soluble (e.g. certain pictures of the English School of the

38. PORTION OF A STILL LIFE BY V. KALF. — APPLICATION OF PHOTOGRAPHIC ENLARGEMENT SHOWING THAT THE GRAPES (WHICH ART CRITICS HAD ALREADY REGARDED AS SUSPECT) ARE REALLY A LATER REPAINT. EXAMPLE OF GENUINE CRACKLES WHICH HAVE PENETRATED THE NON-ORIGINAL LAYER.



39. STILL LIFE BY KALF, SHOWING THE REPAINTED GRAPES, PARTLY OBLITERATED.

XVIIIth century), or for pictures in an exceptional condition—soft or brittle, or for those rare cases where an oil varnish is as hard as, or harder than, the paint beneath. But what will always constitute a danger for any kind of picture is the possibility of its falling into the hands of an inexperienced or inconsiderate restorer.

Any fresh mixture prepared for the purposes of cleaning should be most carefully tested on the edge of unimportant parts of the painting to make quite sure that it is absolutely harmless.

The solvent should be just strong enough to remove the overpaint slowly with gentle rubbing. It may be taken that all the added paint has been removed when a new swab remains clean after continous rubbing on the same spot. The experienced cleaner will nearly always be able to distinguish between tinted varnish, original paint and added paint. When the retouching has been done only a short time after the completion of the original painting, however, the distinction is often difficult, not to say impossible, even with the aid of the various methods of technical investigation. In doubtful cases, the simplest way of avoiding any damage is to leave the suspected layer untouched. The same principle holds good for additions which cannot be removed without risk for the original.

The cleaner should always be on his guard and constantly bear in mind that, very often, certain parts of the same picture are more soluble than others, for example: the dark browns and other black transparent colours, lakes, etc.

When the suitable solvent for the picture under treatment has been found, the exact formula should be noted in the record.

A warning is here necessary against the three following methods of softening varnishes and retouches: cleaning with a swab moistened with a strong, undiluted solvent such as alcohol, and arresting or restraining its action by means of a second swab dipped in turpentine or some other mild solvent; the use of the regeneration box; and, lastly, the laying of blotting-paper soaked with alcohol or other strong solvent on the surface of the picture, and a final cleaning with a dry or damp swab or brush. None of these three methods permits of constant and complete control, for original paint, even that of very old and hard pictures, softens at the same time as the overpaint; this has been proved by tests.

Only a restorer with years of experience as a painter and familiar with all the painting materials and the different ways of using them is, as a rule, able to determine the most appropriate method of cleaning to adopt in difficult cases.

Whenever an old and successful retouching is found, which does not cover

any portion of the original and which has not darkened, it should, as much as possible, be allowed to remain.

Solvents.

165. — Varnish solvents were described in detail in Chapter XII. We will here recall that benzol plus alcohol, for example, forms a strong solvent specially suitable for the removal of paint. Benzol alone is a weaker solvent than alcohol, but a combination of the two produces a stronger solvent, which can be weakened as desired by the addition of turpentine or rectified paraffin oil (petrol). It is sometimes more risky to clean the gilding than any other part of a painting; ethyl-trichloride is generally used for this work. (See §§ 173-175 below on *Gold grounds and Gilding*).

There are today a large number of solvents available and they lend themselves to all sorts of combinations. Many of them are injurious to the health of the person using them.

Old and hardened retouches executed in oil paint, and even comparatively new tempera repaints, can, in many cases, be removed only by a solvent containing a small proportion of ammonia. Such a mixture, used preferably in the form of a soapy paste with wax, oil or balsam, would end by damaging the original paint if left too long on the surface or if it were incorrectly used; when applied by skilful hands, however, it will often give far better results than an absolutely safe process in the hands of a careless operator.

Scraping.

166. — When the dissolving of a repaint is liable to damage the original paint, a mechanical process is adopted; this consists in removing the added layer by scraping or splitting, generally without previous softening. Specially shaped instruments are needed for this work and it is advisable to operate under a fairly strong magnification with a binocular magnifier (×8 to 15 diameters). This method is, in many cases, safer than the use of strong solvents and is frequently resorted to with great success.

Each stage of the process may be controlled not only by magnifiers, but also by ultra-violets rays, which will prove useful in showing up areas on which varnish or retouchings remain.

40. EXAMPLE OF THE TRANSFORMATION OF AN OLD PAINTING INTO A MODERN PORTRAIT WITH CONTEMPORARY COSTUME. THE TRANSFORMATION WAS EXECUTED ON A PORTION OF " THE FALLS " PAINTED BY L. CRANACH THE ELDER. CONDITION OF THE PANEL BEFORE TRANSFER AND REMOVAL OF THE OVERPAINT.

41. CONDITION OF THE PAINTING AFTER TRANSFER AND AT THE FIRST STAGE OF THE STRIPPING OF THE OVERPAINT.

Old Stoppings.

167. — When all the retouches have been removed, the holes and stoppings will be laid bare. Old putty which has become brittle should be carefully removed; old stoppings in good state of preservation and showing no signs of crackle may be left, provided that they are as light as the original ground and cover no portion of it.

Photographic Records.

168. — Photographs should be taken of the different stages of the cleaning operations, but the most valuable record will be a photograph of the picture completely stripped; the most important portions of the picture should be photographed full-size. When dealing with particularly delicate or interesting cases, it will be found useful to take a series of colour photographs or to carry out a few colorimetric tests before and after cleaning.

Stopping.

169. — The holes thus revealed in the paint (which sometimes reach as far as the support) should be carefully cleaned by scraping and filled with putty consisting of a filling material, such as chalk or plaster, bound with a medium (e.g. glue) and made plastic by the addition of small quantities of oil, soft resins, wax or egg-yolk. The filling material should be more elastic for canvas pictures than for panel paintings. It should be tinted to match exactly the colour of the original ground, the principle of modern restoration being to follow as closely as possible the methods adopted for the execution of the original.

Retouching.

170. — When a restorer wishes to imitate exactly the parts that are missing in the original, the only way of achieving this will be to imitate also the principal layers beneath.

Before the putty has completely hardened, it should be levelled and smoothed by wiping, filing or scraping with appropriate instruments (cuttlefish bone, steel-wool, etc.). When dry, the filling material should be just a trifle lower then the surrounding level in order to allow for the paint to be applied.

42. THE SAME PAINTING AFTER REMOVAL OF THE OVERPAINTS.

Imitation of Original Layers.

171. — The priming colour is next applied to the putty, in exactly the same shade as the original, with size or tempera media. The drawing-in or under-modelling is then completed—when this is desired—in the manner of the original, also with an aqueous medium. On this, the underpaint is applied in tempera, in the colours of the original. These colours can be determined by examining, with a magnifier, the areas where the final layer of the original has been removed by scraping or splitting, leaving the lower layer bare.

Already in this layer, not only the correct shading but also the exact degree of translucency is important for a successful restoration. These will, of course, be better matched by using the same pigments as those used for the original.

As a rule, the retouching should be left slightly lighter in tone; interference with the modelling of the master will thus be more easily avoided.

If an exact match of the final glaze is wanted, wax resin colours must be used. (See: *Bibliography.*)

The disadvantage of tempera is that it becomes so hard that it is often difficult to remove; this can be avoided by using a tempera rich in resin and wax.

An intermediate varnish layer of dammar in turpentine under the tempera paint will make it possible to remove the latter more easily. Each coating should be thinly varnished with dammar before the next is applied.

Tempera should always be used irrespective of the technique of the original, even if the original was executed in oils, because oil colour would darken and become more transparent with time, while a tempera layer, varnished and glazed, harmonises much better with the old, transparent (vitrified) oil paint than actual oil paint. The essential rule to be observed in retouching is never to go beyond the area of the missing portion by encroaching upon the old paint.

Abrasions.

172. — Retouching becomes difficult where no definite holes exist, but where, for instance, the upper modelling is partly effaced or worn off by abrasion. Here, the discretion and tact of the owner or curator and of the restorer play a decisive rôle, and there is always a danger of going too far. If, however, care is taken to keep the retouches always a shade lighter than the surrounding colour, interference with the original intention will often be avoided.

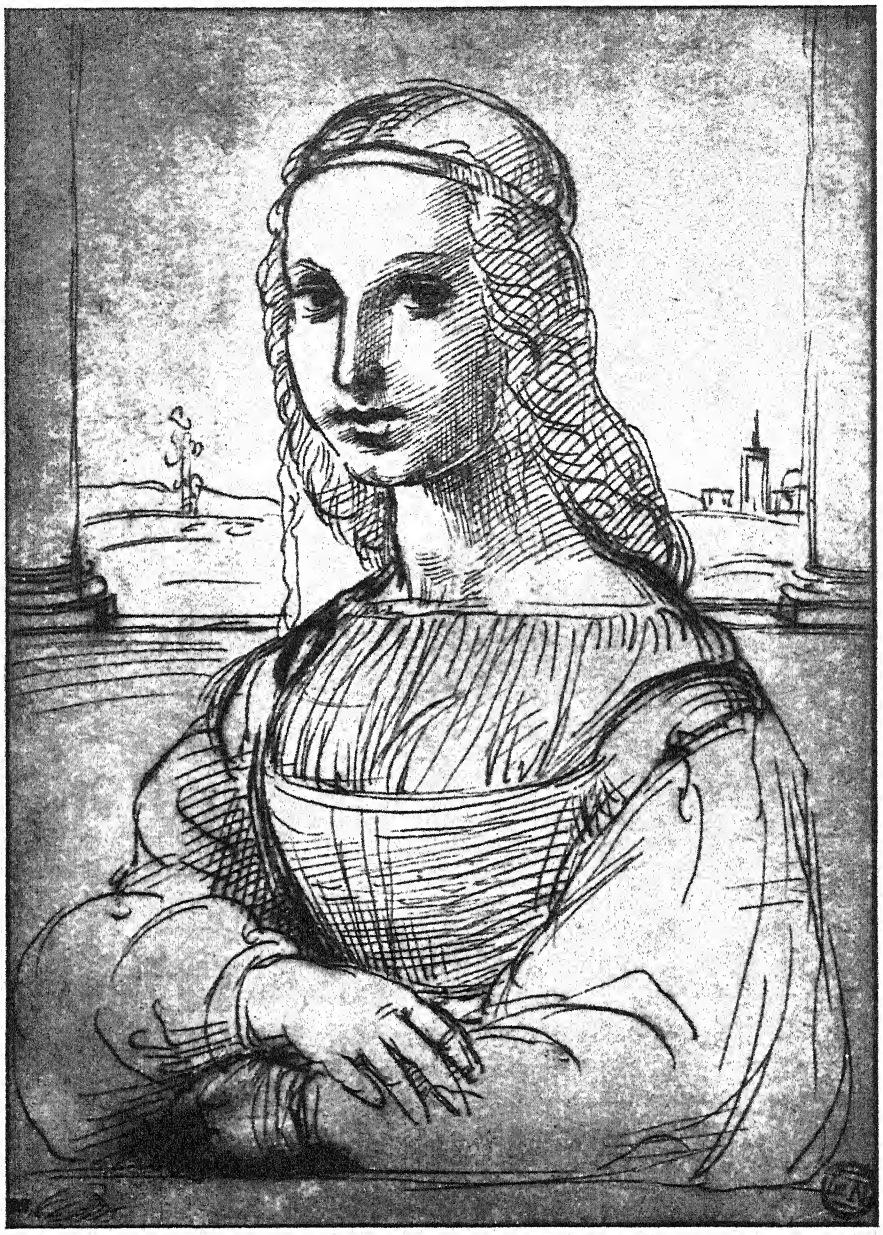
To complete the final modelling that has been worn off, none but resin or wax colours, which can easily be removed, should be employed.

There would be scarcely any objection to the use of water-colours if these were not so difficult to handle; they are nevertheless quite suitable for restoring Italian primitives painted in separate strokes.

When the retouching is finished and dry, the picture is varnished; this protective coating can, in turn, be dulled or glazed in accordance with the methods described in Chapter XII.

43. BORGHESE GALLERY: PAINTING N° 371 BEFORE REMOVAL OF OVERPAINTS AND RESTORATION.

44. BORGHESE GALLERY: PAINTING N° 371 AFTER REMOVAL OF OVERPAINTS AND AFTER RESTORATION.



45. LOUVRE MUSEUM: SKETCH BY RAPHAEL, CONFIRMING THE ASSUMPTIONS AS TO THE APOCRYPHAL MODIFICATION OF RAPHAEL'S WORK AND ITS ATTRIBUTION. (SEE FIGS. 43 AND 44.)

D. — GOLD GROUND. — GILDING.

General Treatment.

173. — When treating gold grounds and gilding, the principles to be observed will be the same as for paint, and the same treatment should be applied for blistering and other deteriorations of the paint layer. Special care is, however, necessary when using water: the bolus on which most gilding is applied is very susceptible to water and the gold is so thin that it does not provide sufficient insulation.

Cleaning.

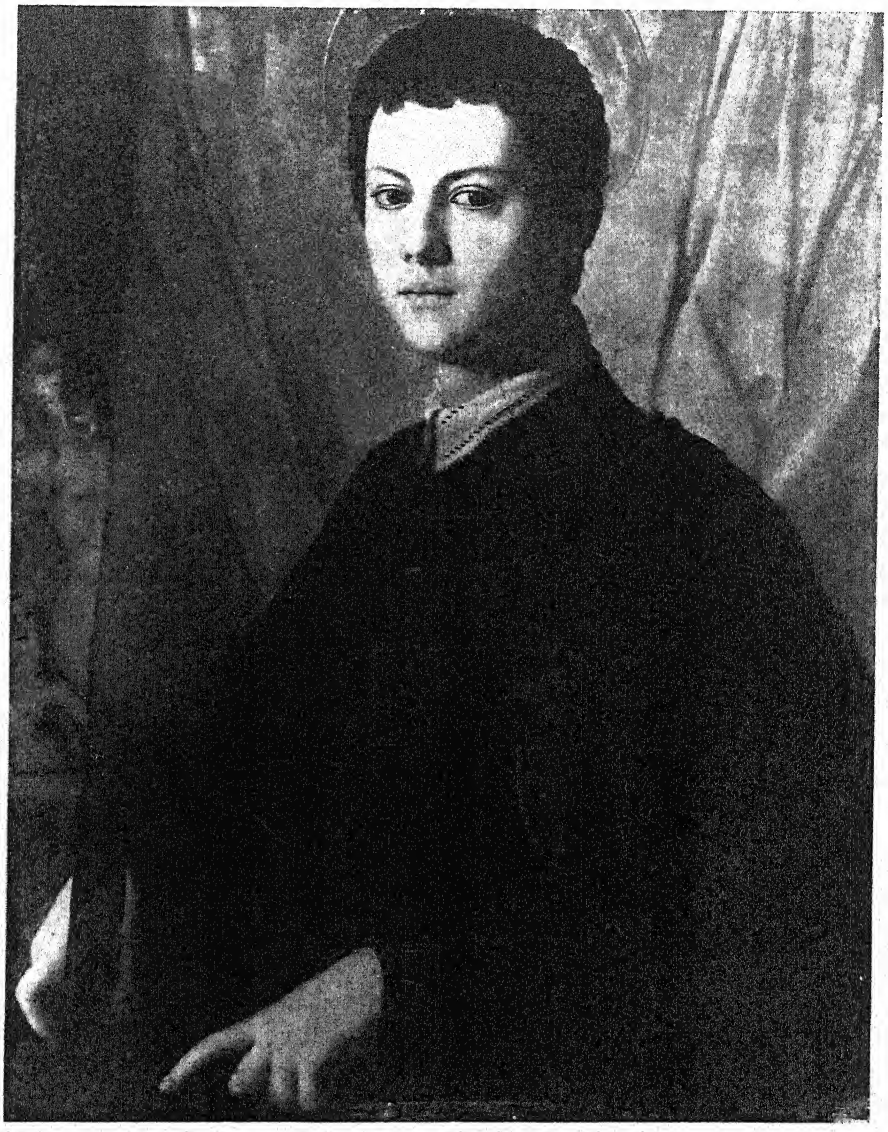
174. — When cleaning gilding, it must be borne in mind that gold grounds are sometimes covered by a layer of dark varnish, which may be original and intended to attenuate the brilliance of the gilt. This mat covering should be respected whenever there is reason to suppose that it existed in the original work.

Another reason for not subjecting the gilding on some paintings to a radical cleaning is that, in many cases, it is better preserved than the actual colours and might become too conspicuous if thoroughly cleaned.

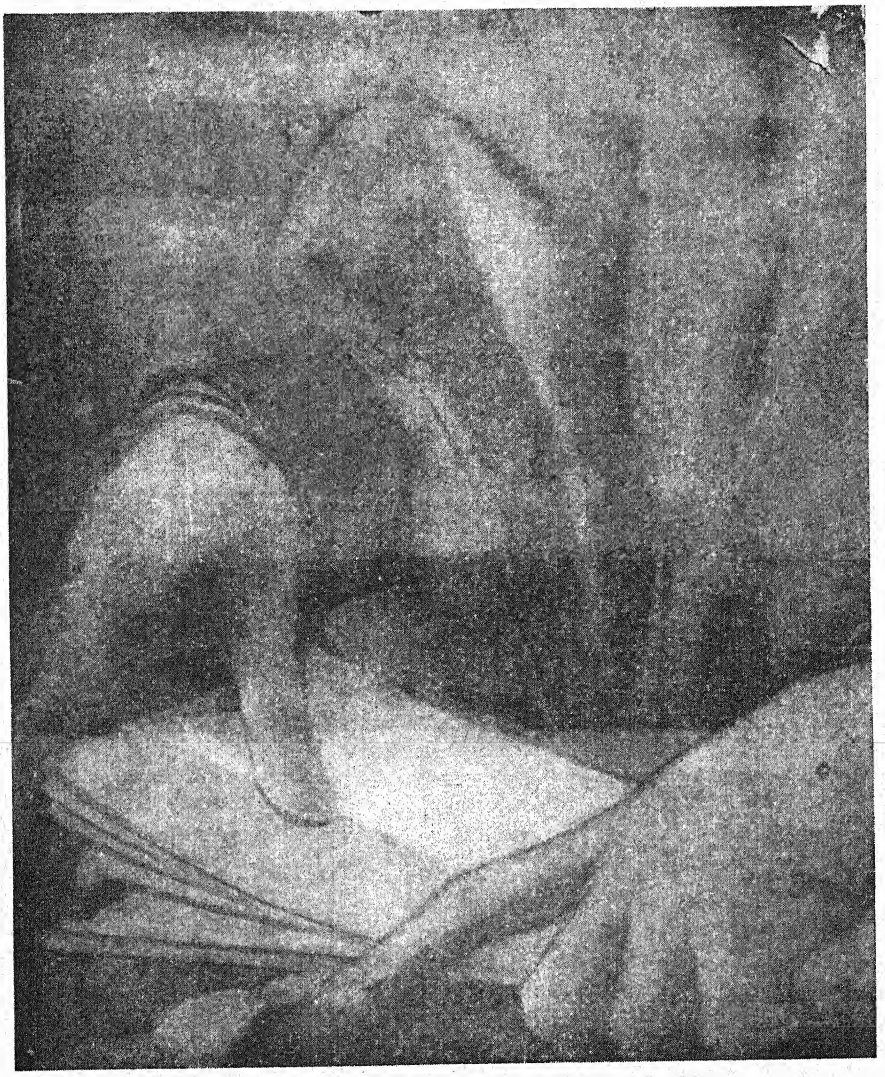
Gilding is not only particularly sensitive to the action of agents containing water, but very often also to that of alcohol, and still more so to that of ammonia; in the majority of cases, therefore, solvents of the hydrocarbon type—ethyl-trichloride, etc.—which are safer for this kind of cleaning, should be used. Repaints executed in gold or bronze can often be removed with these agents without risk of damaging the original gilding. Special care must be exercised when treating a gilt prepared with an oil medium, which, of course, reacts to different solvents.

Retouching.

175. — Generally speaking, one should practically never attempt to replace damaged portions of gilding with new gold; the treatment should be confined to retouching in the bolus colour (mostly red, but sometimes yellow or grey). There are, at present, very few gilders (frame-makers for the most part) who would be capable of reconstituting a seriously damaged or missing portion of old gilding in the right quality and tone, and still less of manipulating the punch in the correct way.

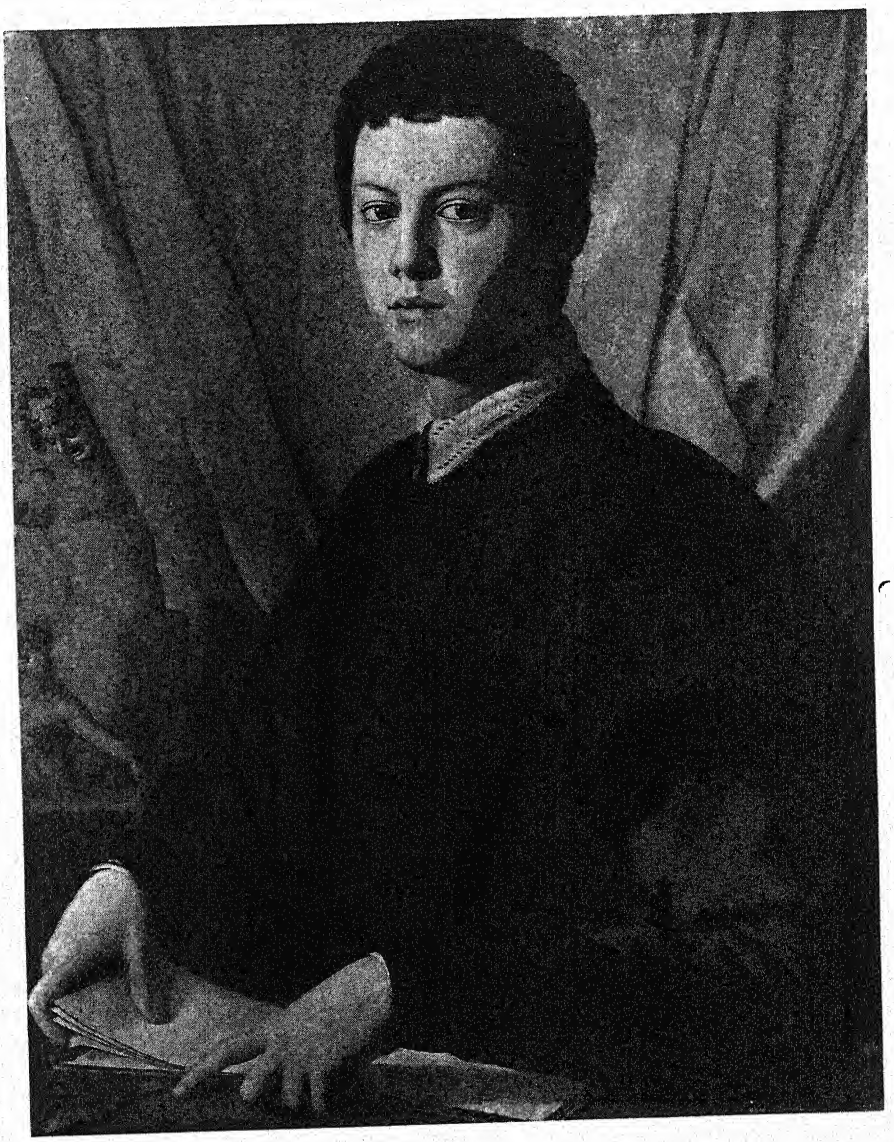


46. BRONZINO, PORTRAIT OF A MEDICI BEFORE CLEANING. THE FAULTY QUALITY OF THE ARMOUR, THE RIGHT HAND, ETC., HAD CREATED SUSPICION. THE RIGHT HAND WAS RADIOGRAPHED (SEE FIGS. 47-49.)



47. RADIOGRAPH OF THE RIGHT HAND (DETAIL OF THE PORTRAIT BY BRONZINO) SHOWING A SECOND THUMB AND A BOOK. ON THE BASIS OF THESE DATA AN EXPERIMENTAL CLEANING WAS CARRIED OUT, WHICH SHOWED THAT THE REPAINT COULD BE REMOVED WITHOUT ENDANGERING THE ORIGINAL AND THAT THE LATTER WAS IN A GOOD STATE OF PRESERVATION. (IN THE ABOVE REPRODUCTION, THE BACK OF THE FOREFINGER AND THE UNDERSIDE OF THE THUMB HAVE BEEN OVER-ACCENTUATED IN THE RETOUCHING.)

48. CONDITION OF THE PICTURE DURING THE PROCESS OF CLEANING. THE DARK VARNISH AND THE OVERPAINT HAVE BEEN REMOVED EXCEPT IN THE FOUR RECTANGLES: A SMALL RECTANGLE IN THE TOP RIGHT-HAND CORNER; A LARGER RECTANGLE ACROSS THE FOREHEAD, SHOWING TWO DIFFERENT LAYERS OF VARNISH; A THIRD, ON THE LEFT, ABOVE THE STATUE, SHOWING TWO LAYERS OF TINTED VARNISH AND A REPAINT; AND, LASTLY, A LONG HORIZONTAL RECTANGLE ACROSS THE BUST, WHERE A PORTION OF THE REPAINT, REPRESENTING ARMOUR, HAS NOT BEEN REMOVED. PART OF THE HALO, THE FLAGSTAFF AND THE THUMB OF THE HAND HOLDING IT (ALL LATER ADDITIONS) ARE STILL VISIBLE AT THIS STAGE OF THE CLEANING OPERATION. A FEW DETERIORATIONS, NOT VERY APPARENT IN THE REPRODUCTION OF THE PICTURE AS IT WAS BEFORE TREATMENT, MAY BE SEEN, PARTICULARLY BETWEEN THE STATUE AND THE ARM.



49. CONDITION AFTER RESTORATION: ON COMPARING IT WITH ITS PREVIOUS CONDITION, IT WILL BE SEEN THAT THE PORTRAIT HAD BEEN TRANSFORMED INTO THAT OF A SAINT: CURTAIN REPLACED BY A FLAG, ADDITION OF A CROSS AND A HALO, AND SUBSTITUTION OF ARMOUR FOR THE TUNIC. THE ATTRIBUTION OF THE PICTURE TO BRONZINO IS NO LONGER DISPUTED. (IN THE ORIGINAL, THE CONTOURS OF THE STATUE ARE LESS MARKED THAN IN THE PHOTROGAPH ABOVE.)

CHAPTER XIV

MALADIES AND TREATMENT OF THE GROUND

Definition.

176. — The ground or preparation of a picture is a film of uniform colour, containing pigment particles and having some appreciable body or thickness, which is spread over the support. On this ground, the drawing and the various colours of the paint film are laid. (The support is usually composed of wood or canvas, or, in rare cases, of stone or metal.)

Types of Ground Films.

177. — Since the film-forming material or the adhesive which holds the pigment or inert substance of the ground is the most important constituent so far as its deterioration is concerned, a ground can be practically classified according to the general characteristics of the binding medium used for it. These media are: 1) crystalline; 2) aqueous, or 3) oleaginous.

In easel paintings, the crystalline type of medium is probably rare. It may be found particularly on early Italian panels where the *gesso-grosso* is made up of gypsum with no film-forming adhesive, or in recent paintings if sodium or potassium silicate has been used as the medium.

Aqueous grounds are those in which a water-dissolved medium holds the inert ingredients together. Almost all of these media remain more or less responsive to the action of water or water-vapour. Casein, of course, would not be responsive, but it has so rarely been used in primings that it need not be made a separate type. Glues, gums or emulsions rich in glue belong to this class.

The oleaginous grounds include those bound with resin and oil or oleo-resin and oil mixture, and emulsions rich in oil, as well as those bound with pure drying oil. When thoroughly hardened, these are soluble only in organic solvents.

It might be said that a fibrous material, like paper, interposed between the

canvas or panel and the paint film, constitutes another type of ground. Such a ground was used in the XVIth century and later, and it is found in a number of paintings by Holbein. A recent writer has recommended it (see an article by John Lyman: *Paper as a Ground for Oil Painting*, Technical Studies, I (1933), pp. 207-211). But properly speaking, paper used in this way is a part of a compound support and should be so considered.

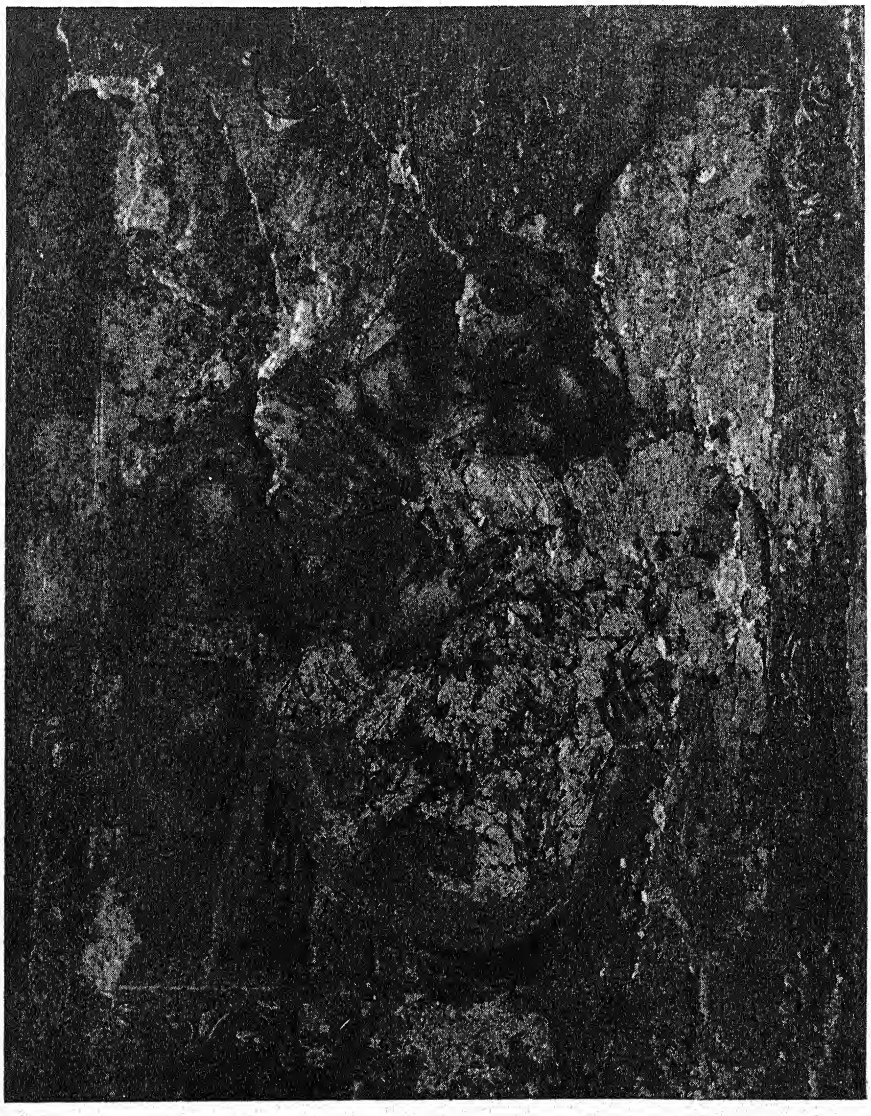
Structure of the Ground and relation to other parts of the Painting.

178. — The common types of ground—the aqueous and the oleaginous—consist of dried films of medium tightly packed with crystals of chalk ($CaCO_3$), gypsum ($CaSO_2$), lead white ($Pb(OH)_4$. $2PbCO_3$), red earth, or like substances in combination.

Tight packing of the inert ingredients is necessary, particularly with the aqueous type of preparations, where drying by evaporation results in immediate film fractures if the crystals are not close enough together to restrain the shrinkage, In the oleaginous type, this shrinkage does not occur for years and the defect of excess medium may not be apparent until too late. The mat surface required in a priming for practical reasons has, however, led to the incorporation of a small quantity of medium in proportion to pigment.

As regards the composition of the ground throughout the centuries, A. de Wild, in his study of the materials in a series of Netherlandish paintings, found only chalk. Analyses, however, have often shown the presence of gypsum. About the XVIth century, Italian paintings on canvas frequently had a red ground, and lead white, mentioned by Vasari, is common in the oleaginous grounds of later periods. A. P. Laurie (*The Materials of the Painter's Craft*, London and Edinburgh: T. N. Foulis (1910), pp. 357-364) records a number of Renaissance methods of grounding canvas and panels, and a careful study of these developments is made by Alexander Eibner in *Entwicklung und Werkstoffe der Tafelmalerei* (Munich, Heller, 1928, pp. 90-115).

This film may be held to the canvas or wood of the supporting ground by a mechanical bond, the intruding parts of the ground film being locked in the interstices of the threads, in the voids between the fibres, or in the roughened surface of wood. The support is usually primed with a glue size before the ground is applied. This intermediate film, applied at first in dilute solution, sinks deeper into the material than the thicker ground film could, With oleaginous films, this prevents absorption of oil by the canvas on which such



50. SMALL XVIITH CENTURY GREEK IKON, IN WHICH THE PULVERULENCE AND SPLITTING OF THE PRIMING ARE EVIDENT. THE PRIMING IS OF THE USUAL ""GESSO"" TYPE. — AQUEOUS MEDIUM WITH PLASTER AS INERT COMPONENT. THE DETERIORATION OF THE MEDIUM PROBABLY CONTRIBUTED TO THE PRESENT STATE OF THE OBJECT AND PREVENTED THE PRIMING FROM FOLLOWING THE MOVEMENT OF THE WOOD AND REDUCED ITS COHESION TO SUCH AN EXTENT THAT THE PAINT LAYER, MORE FIRMLY BOUND, BECAME DETACHED AND FLAKED.

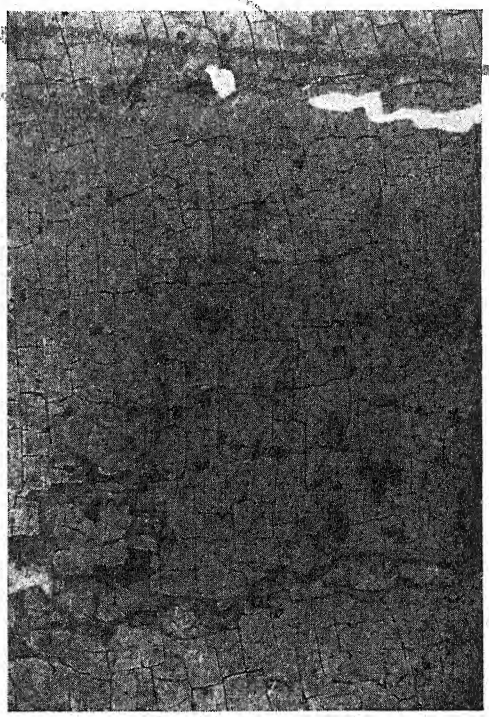
films usually lie. The relation of the paint film to the ground depends on the binding medium employed. Aqueous films on oleaginous grounds are practically unknown, although it has been suggested that oil-resin over gesso was used under tempera films in Flemish painting (1). Oleaginous paint films on aqueous grounds are much more common, and in view of the analyses by A. de Wild mentioned above, one may judge that such a combination must have continued well into the XVIIIth century. When oil paint is laid on this gesso type of ground, adhesion between the paint film and the film below it is mechanical, the oil sinking into the pores beneath. When oil with its usual modern diluent—turpentine—is laid on a ground also bound with oil, there is probably a slight solution of the under film and a resulting bond that is practically a union of the two. In the presence of such a union, any defects will, of course, run through both.

Kinds of Deterioration in Ground Films.

179. — Mechanically, there are three kinds of deterioration which can be noticed in the grounds of old paintings: pulverisation, rupture, and cleavage. The first two are products of increasing brittleness, loss of flexibility, hardening, shrinkage, and, in some cases, of actual decomposition of the binding medium (Figs. 50 and 51). Frequently, both rupture and pulverisation are present, but the former is far the more prevalent, being the condition known as crackle or crackling. While the ground film is fresh, whether it happens to be aqueous or oleaginous, it is elastic. The support at this time, and for as long as it retains any continuous texture, responds actively to changes in humidity and temperature and is, therefore, constantly moving. While the ground film remains elastic, it can move also, staying with the support, and being stretched or compressed in the same plane. In an aqueous binding medium, there occurs a gradual hardening and weakening of this originally elastic film, the result to some extent of an actual release of moisture with reduced ability to take up moisture again from the atmosphere. It is possible, also, that micro-organisms of a bacteriological kind live in these glue and gum films, slowly utilising them as food.

The oleaginous grounds are not soluble in water, but an old oil film may be

(1) See Max Doerner: *Malmaterial und seine Verwendung im Bilde* (Munich, Weizinger, 1922), p. 291, and Léon van Puyvelde: *La technique des peintres Flamands du X^e siècle*, Annuaire général des Beaux-Arts de Belgique (1931), pp. 113-120.



51. DETAIL OF AN EARLY XIVTH CENTURY FLORENTINE PANEL, SHOWING BREAKS AND SPLITTING. THE PROGRESSIVE HARDENING OF THE MEDIUM IN THE AQUEOUS PRIMING HAS CAUSED THIS LAYER TO BREAK INTO CRACKLES OF CHARACTERISTIC PATTERN, UNDER THE CONSTANT STRESS EXERTED BY THE EXPANSION AND CONTRACTION OF THE WOODEN SUPPORT.

hydrophilic. This, however, is not the principal cause of *rupture* in such films and the observation from general experience that they are rarely pulverised makes it seem highly improbable that decomposition from bacteriological causes is ever serious. The deterioration of such films is chemical in its nature, resulting largely from a process of oxidation lasting over indefinite periods of time (1). In consequence of this oxidation, the film becomes more brittle and its inability

(1) A. P. Laurie suggests that this change may continue during centuries. See: *On the Change of Refractive Index of Linseed Oil in the Process of Drying and its Effect on the Deterioration of Oil Paintings*, Proceedings of the Royal Society, CXII (1926), Series A, pp. 176-181. Eibner: *Entwicklung und Werkstoffe der Tafelmalerei*, pp. 51-66.

to follow the movements of the support brings about a rupture more or less like that of the aqueous ground.

The cause of cleavage is similar. When the ground film becomes ruptured or cracked, the small openings or apertures lying at right angles to the surface may allow a play in this film sufficient to take up expansion and contraction in the support. If that play is not sufficient, the adhesion of the ground to the support will be broken. This is usually accompanied by crackling or rupture of the film but is distinct from that because it involves an actual separation from the support. Cleavage, therefore, occurs in the plane of the film; rupture, in a direction approximately at right angles to it.

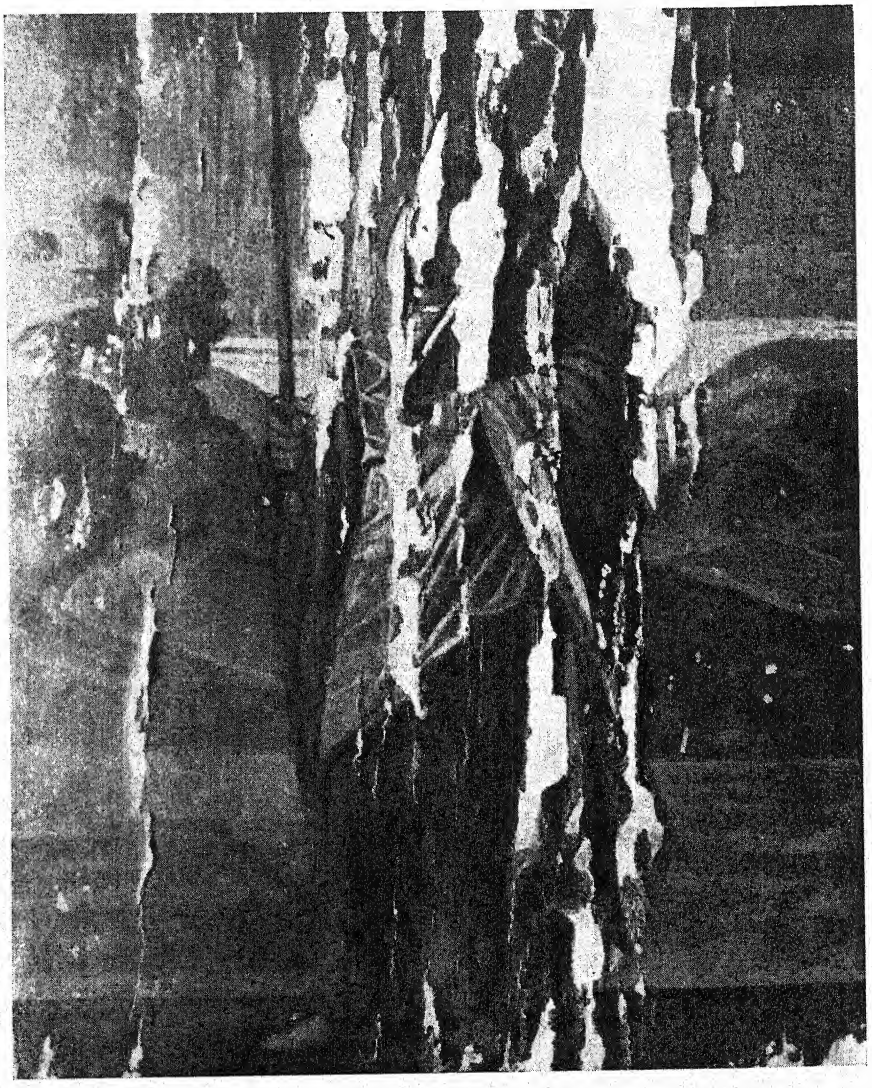
Signs of Deterioration.

180. — The two dangerous aspects of this general tendency towards pulverisation, rupture and cleavage are:

a) increasing concavity of the islands of ground and paint film lying inside the crackle lines, sometimes with a tendency to complete separation or cleavage —the condition known as scaling (Figs. 50 and 51);

b) separation or cleavage occurring under a continuous film with a tendency to make the film buckle or rise from the support—the condition known as *blistering*.

Naturally, these defects in the ground film carry with them corresponding and usually parallel conditions in the paint films, and there may be some doubt as to where the actual defect lies. It is less usual, however, in old paintings to find scaling and blistering in the paint film alone than to find them in the ground. The danger of either defect is obviously the complete loss of paint, in the area that suffers. A further danger follows; when there is loss by scaling, air, with its varying content of humidity, is admitted more freely to the under structure of the paint and the development of scales and blisters will probably occur at a more rapid rate (see Fig. 52). In ordinary gallery examinations, tendencies toward flaking or blistering can be observed by placing the picture in a shaft of raking light or in a vertical light, or by moving the point of observation so that the angle of reflection is caught directly by the eye. Either vertical or raking light will minimise the colour and value contrasts in the painting and will give full effect to variations in texture and in plane. If a noticeable concavity or convexity of parts is found, the painting should be subjected to a careful expert examination to discover the extent and depth of lifting or cleavage. In

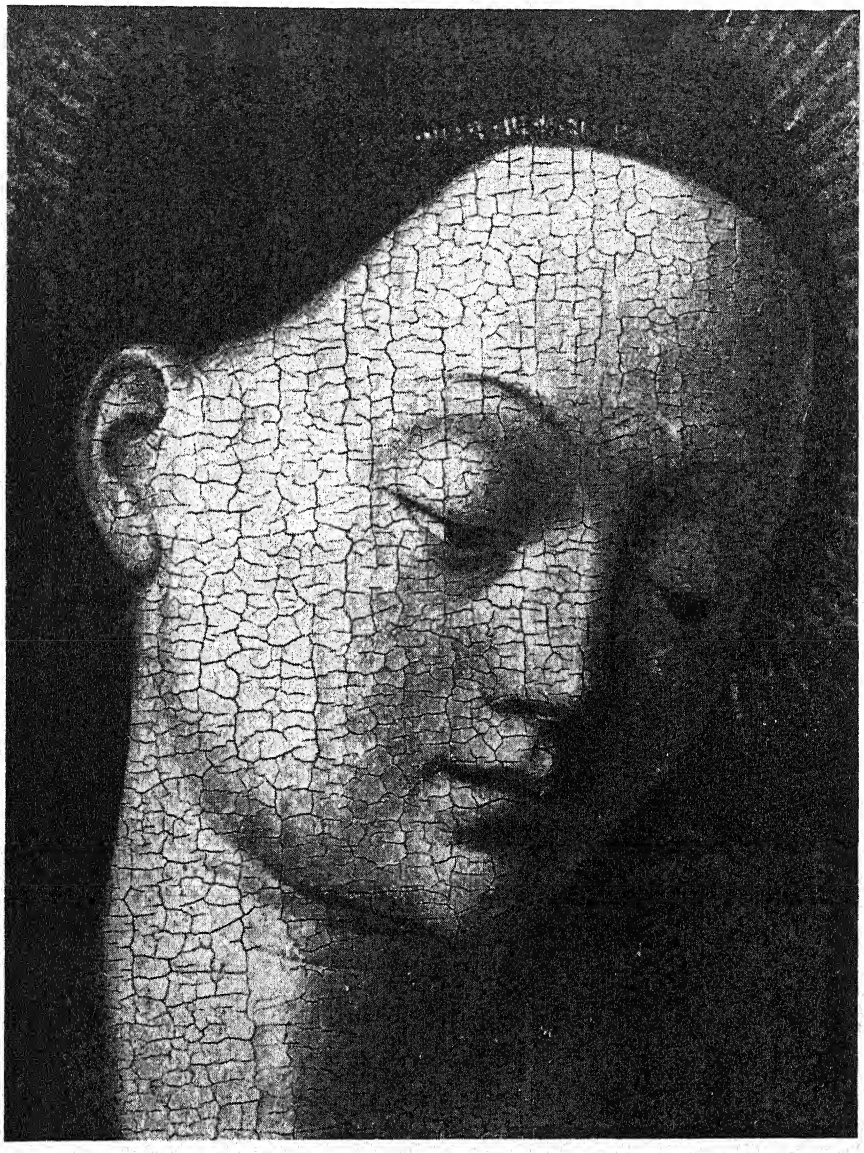


52. SPLITTING AND BREAKING OF THE PRIMING IN A VENETIAN PANEL EXECUTED ABOUT 1500. REDUCED ELASTICITY OF THE AQUEOUS MEDIUM AND THE EXTREME CONTRACTION OF THE PANEL HAVE CAUSED THESE FISSURES TO DEVELOP AND HAVE SEPARATED THE PRIMING FROM THE SUPPORT, WITH RESULTING GAPS IN THE PRIMING AND THE PAINT LAYER.

some cases, particularly in old panel paintings where the wood is very weak, deep cleavages will occur which are not visible at the surface. The reason for this is often the presence of a linen support between the gesso and the wood, or embedded in the gesso proper. Such a support gives tensile strength to the ground film and, because of it, actual treatment can often be safely delayed or even avoided entirely. · Clefts are usually found by sounding the surface, but even this simple method of examination is not safe unless used by someone skilled and experienced. Attempts to determine the condition of a film by tapping it, may cause mutilation.

Treatment.

181. — In extreme cases of pulverisation, it may be necessary to transfer the painting, Usually, such a general deterioration of the priming film occurs in thick primings of gesso and may result, in the crystalline type, from disintegration of the gypsum. Usually, also, it is accompanied by extensive decay in the wooden panel and this requires transference to effect a remedy. Comparatively, however, these cases are rare and the usual treatment given to ground defects is flattening and re-setting of blistering and scaling films. A great number of techniques and a variety of combinations of adhesive materials have been developed for these operations. At present, it may be said that if the capability of the restorer and his experience in dealing with this condition are established, the actual technique or manipulation can be taken as acceptable. As to the question of the adhesive material, an exact answer is impossible, for that material will have to be adjusted to the case in hand. A warning may be entered, however, against the indiscriminate use of glue or similar aqueous solutions. In cases where the paint film itself is soluble in water, these solutions could hardly be considered at all; but even where the paint film is oleaginous, dangers are involved in the use of such adhesives, It must be remembered that to make a secure union some degree of heat and a certain amount of pressure are usually required. Heat applied to a submerged glue or gum film in a gel or semi-dry state rapidly drives off water in the form of vapour or steam. This vapour must find its way out to the surface and, in so doing, is obliged to filter through the tissues immediately surrounding the locality treated. If these tissues are composed, so far as their binding medium is concerned, of an old and considerably oxidised oil film, they will be hydrophilic, that is, capable of absorbing some amount of moisture when this is carried through them in



53. CRACKLE OF THE PRIMING AND THE PAINT LAYER, TYPICAL OF NORTHERN PAINTINGS, MID-XVTH CENTURY, PROBABLY DUE TO THE TRACTION EXERTED BY THE WOOD ON THE PAINT LAYERS.

such a form. The inevitable result is swelling of these tissues, with subsequent shrinking and with the danger of further cleavage adjacent to that already treated.

The chapters dealing with the paint layer and the various types of supports give a detailed description of a series of treatments, which necessarily apply also to the ground; those chapters should therefore be consulted for complementary particulars of a practical character in connection with this scientific study of the structure and function of the ground film (§§ 144-156).

CHAPTER XV

MALADIES AND TREATMENT OF CANVAS

A. — TEXTURE, CHARACTERISTICS, PROPERTIES

Uses.

182. — Woven linen fabric was used, in conjunction with papyrus, in Ancient Egypt for the construction of the painted cartonnages of mummies. It was also used in the East for covering wood which was to be decorated with lacquer, and for covering the joints of the wooden panels required by the mediæval tempera painter. It was not until the XVth century that it began to be used alone as a separate support for painting. When used in this way, it had the merit of being light in weight and allowed the artist to execute easel paintings on a much larger scale than was possible when his work was restricted to the wooden panel.

Texture.

183. — The name "canvas" is applied to any woven fabric which can, in itself, form a suitable support for painting. The textiles most commonly used for this purpose are made from linen and hemp. These are strong and durable. Cotton is lighter in weight and less satisfactory.

When used as a separate support for painting, the canvas has to be sized and primed, that is, covered with a ground which shall fulfil the twofold function of protecting the fibres from any deleterious action on the part of the binding media or pigments. There are thus two classes of artist's canvas: 1) the raw cloth (unprimed) canvas, used for repair work (patching and relining) and 2) the prepared or primed canvas, used for painting.

Characteristics.

184. — The best canvases for use by the restorer or the artist are woven entirely from the same kind of thread in warp and weft. The canvas should be reasonably heavy and tightly woven, so that it does not require an excessive amount of priming to fill the interstices in order to form a suitable painting ground; the threads should be free from knots.

When these conditions are satisfied, the weaving (tabby or twill) is of less

importance. The plain or tabby weaves are the commonest; fancy twill weaves are chosen for special work, e.g. portraiture; coarse weaves give texture and character; fine weaves and lighter canvases are used for more delicate work.

Influence of Temperature and Humidity.

185. — Canvas reacts characteristically to changes in the hygrometric condition of the atmosphere. When the humidity is relatively high, the threads contract, and, if the fabric has been stretched on a frame it tightens. Under normal conditions, the fibres carry about 12% of moisture. Excessive dryness, as is caused sometimes when a picture is hung over a fireplace, causes dehydration and the canvas expands and is, moreover, weakened as a result of desiccation.

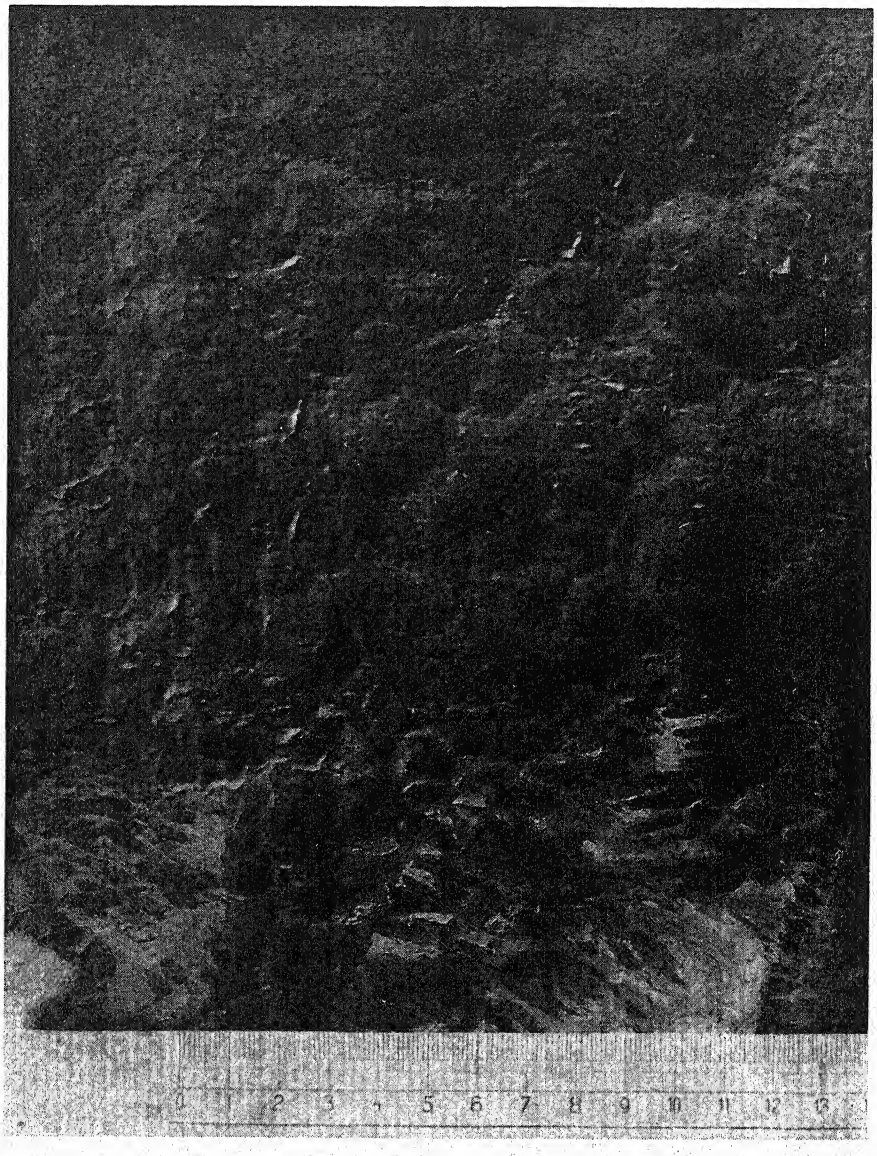
The effect of these changes is notably lessened when a picture has been backed by another canvas (relined), because the adhesive which is used to unite the canvases and which penetrates the threads renders them less susceptible to external influences.

The paint layer itself is influenced by atmospheric changes, in the opposite direction to the canvas, though to a smaller degree. It contracts on desiccation and expands slightly under moist conditions; this explains why painted canvases are, on the whole, more prone to suffer from the flaking away of the paint than is the case with painted wooden panels. (See also §§ 43 and 44).

The Stretcher.

186. — In order to keep the canvas absolutely flat, a wooden stretcher is employed which is capable of adjustment by keys. For small canvases, a plain rectangular stretcher is all that is required; for larger canvases, the stretcher has to be reinforced by cross-pieces so that it will not twist during the straining of the canvas—either in the process of mounting or if the fabric tightens in damp weather.

All the wooden members of the stretcher should be bevelled or chamfered so that the wood touches the canvas only round the edges and the canvas does not adhere to the flat surfaces of the framing; cross members should be kept at least 1 cm. from the back of the canvas and if this precaution is not taken a pattern of cracks appears in the ground and paint layer, marking the edges of the wooden members and irreparably damaging the painting. The canvas should be stretched uniformly and mounted so that the warp and weft threads are parallel to the sides of the stretcher.



54. RESULT OF DEFECTIVE RE-LINING WITH A SIZE ADHESIVE: CRACKLES AND DENTING HAVE APPEARED ON THE SURFACE OF THE PAINTING (SCALE GRADUATED IN CENTIMETRES).

Manifestations of Decay.

187. — When a canvas is woven from weak fibres, such as jute, or from fibres of poor quality, the strength is often largely that of the sizing or 'batter', and when this decays the canvas rots. But even the best canvases do not last indefinitely. Although cellulose is normally chemically inert and very stable, it becomes brittle by oxidation, and this is accelerated by contact with a drying oil. To counteract this oxidation, the fibres are protected by a coating of size before the application of the priming. Glue size is commonly used and is perfectly effective so long as the canvas is kept reasonably dry. It is nevertheless a nutrient material for moulds and bacteria, which not only destroy its protective qualities, but rot the canvas itself. This takes place most quickly in a damp heat and is of chief significance when, for any reason, canvases have to be stored in cellars.

A weakened canvas may be further damaged by being over-tightened in hot weather. When the air becomes cooler, the canvas may be torn as a result of the increased strain imposed upon it by the deposition of moisture. A more rapid and insidious type of damage results from quick changes in atmospheric conditions, as, for example, when a sensitive canvas is exposed in a room heated by steam radiators, which quickly lose their heat when the steam is shut off. When the air cools, the humidity is increased and deposits in the surroundings. The constant movement of the canvas and the continuous readjustments that take place in the paint layer cause accelerated deterioration.

Even under the best conditions, a painting on canvas cannot be expected to last indefinitely, and there comes a time when it must be relined if it is to be preserved.

The processes of reinforcing, or even of replacing, the old canvas have been so perfected today that there are grounds for believing that, in spite of its ephemeral nature, canvas is still the most desirable form of paint support.

B. — GENERAL MEASURES OF PROTECTION

Atmospheric Conditions.

188. — It follows from what has been said regarding manifestations of decay that the principal causes of deterioration are: *a*) moist heat, which encourages the growth of bacteria, and *b*) constant changes in the hygrometric conditions of the air, which result in accelerated weakening of the paint film. Preventive measures are therefore concerned with maintaining the temperature and humidity as constant, as possible, within reasonable limits, say 60-80° C. and 55-65% relative humidity.

Position of Paintings.

189. — If there should be any reason to doubt that conditions in a gallery are not absolutely favourable, measurements of temperature and humidity should be taken in different parts of the room over a period of some weeks or months as the case may be. If a picture is pasted into a glazed frame, the variations to which it is exposed will be less intense than those which obtain in the room, and therefore some such type of mounting is an important precaution when it is difficult or impossible to control the atmosphere of the room itself within the required limits.

Gas Fumes.

190. — The rotting of canvas is accelerated by gas fumes and by the fumes of burning coke which contain sulphur dioxide gas. Consequently, the question of adequate ventilation becomes important, for example in churches heated by coke stoves where valuable pictures are on exhibition.

Heating.

191. — Reference has already been made to the dangers of hanging pictures over a fireplace, because of the risk of damage by excessive dehydration. Similar precautions are necessary in rooms where the panel heating system is adopted: heat may be concentrated at certain points in the wall of the room and the

curator can only discover by using a thermometer how the heat is distributed and hang his pictures accordingly, so that they are not exposed to extremes.

Tension of the Canvas.

192. — In spite of all possible precautions, it will be found that many canvases suffer a seasonal expansion and contraction; it then becomes necessary to make suitable adjustment of the stretcher keys. Over-tightening of the canvas must, however, be avoided at all costs, for the consequences might be disastrous should the canvas then contract under the influence of a sudden increase in humidity.

When, notwithstanding all these precautions, the original canvas becomes weakened, the only way of saving the picture will be to reinforce or replace the support. There is no other method that is really effective for strengthening an old canvas.

Protection of the Back of the Canvas.

193. — In order to protect the back of the canvas from mechanical damage, and to insulate the painting from the wall, a protective sheet (aluminium, ply-board, cardboard or canvas) may, with advantage be nailed or screwed on to the back of the stretcher. If the material chosen is impervious to air, it should be perforated to allow of the free circulation of air and so prevent growth of mould. A metal backing is required only in the event of transport.

C. — CARE AND TREATMENT

I. Local Repairs.

Bulges and Dents.

194. — Mild cases of bulges and dents can very often be corrected by moistening the back of the canvas with a saturated solution of alum in water and then applying a hot iron (see below: *Ironing*). A bulge in the canvas is frequently due to some body which has fallen between the canvas and the stretcher (wedge, nail, plaster, etc.). Once this body has been removed, a thin sheet of stiff cardboard can be inserted between the stretcher and the canvas and the ironing done from the front.

Patching.

195. — When a canvas painting is torn, it should, as a rule, be relined. But when the value of the picture does not warrant the expense of complete relining, a patch can sometimes be applied with success.

The most suitable material for a patch is very thin muslin; a piece slightly larger than the area of the damage is soaked in the usual warm-lining mixture (see below) and pressed evenly on the back of the tear. The loose threads of the canvas and particles of paint along the edge of the tear are carefully put back into place with tweezers or some similar instrument and pressed down into the adhesive of the patch. A sheet of parchment paper is next laid over the back and front of the picture and the torn area ironed, on the front, with a flat iron heated to about 60° C., on a flat and even table. When pastose brushwork is present, a layer of felt should be placed over the parchment paper when the painting is ironed from the front.

The use of any material thicker than muslin, and of animal glue as adhesive, would cause the canvas to bulge owing to the contraction which takes place on drying. Muslin and the adhesive recommended below will prove quite strong enough.

When a canvas shows a serious bulge and when the paint film has been marked by the edges of the stretcher, the picture must be relined.

II. Relining.

Definition.

196. — The lining process which consists in stretching a new canvas on the back of the original support is now generally referred to as "relining". This is not correct, because "relining"—in the true sense of the term— would imply the removal of the original canvas and replacing it by a new one. This process is usually called "transfer" (see below, §§ 216-224).

Cases requiring Relining.

197. — Relining is often carried out as a preventive measure for paintings that are still in good condition, on the assumption that all canvas paintings will, sooner or later, have to undergo this treatment. There are, however, cases of well-preserved canvas paintings, several centuries old, which do not yet need relining. There is not much to be said against relining as a precautionary measure, if it is properly executed, except that many curators maintain that paintings should be interfered with as little as possible.

The chief reasons for relining are: general brittleness or flaking of the ground or paint layer (see Chapter XIII); very often, these layers may still be in a fairly good state of preservation, but the canvas itself has become so brittle or weakened that it needs reinforcing. When a canvas has not been sufficiently isolated by a coating of size before the application of the oil paint, or when it has been oiled from behind, the acid formed during the oxidation of the oil gradually destroys the canvas. This would appear to be a more frequent cause of disintegration than moisture, mould, etc.

Function of the Adhesive.

198. — All adhesive mixtures used for lining are melted by heat during the process; they successively penetrate the new canvas, the original canvas and fill the crackles in the priming as well as of the paint layer, ultimately reaching the surface of the paint. As will be seen later, it is possible to verify that the impregnation has reached the paint film: the paper used as a surface protection will show traces of the adhesive if the latter has really penetrated into the crakles. (Fig. 56).

The function of the adhesive is not only to hold the new and the old canvas

together in an efficient and lasting way, but also to penetrate the original canvas and the priming, and to secure any particles of paint that may be loose or separated by cracks. It should, at the same time, preserve the canvases from disintegration without altering the optical properties of the ground or of the paint layer.

Composition of Adhesives.

199. — There are two groups of adhesives that can be used for relining: glue paste, and wax resin mixture. These two preparations are not irreconcilable; glue or wax alone is rarely used for relining nowadays: glue without the addition of a balsam is not sufficiently elastic and would be too sensitive to damp and mould; on the other hand, wax without the addition of a certain quantity of resin would not, in the majority of cases, be sufficiently adhesive. Moreover, a painting relined with wax alone as the adhesive could not be satisfactorily revarnished; the wax which works its way through from the back, at least in the parts which are crackled, would deteriorate practically any varnish applied to the surface of the picture.

The fact that, in common parlance, the expressions "glue method" or "wax method" have been adopted (whereas glue and wax are, in both cases, only the prevalent ingredients) has given rise to much misunderstanding and unnecessary controversy.

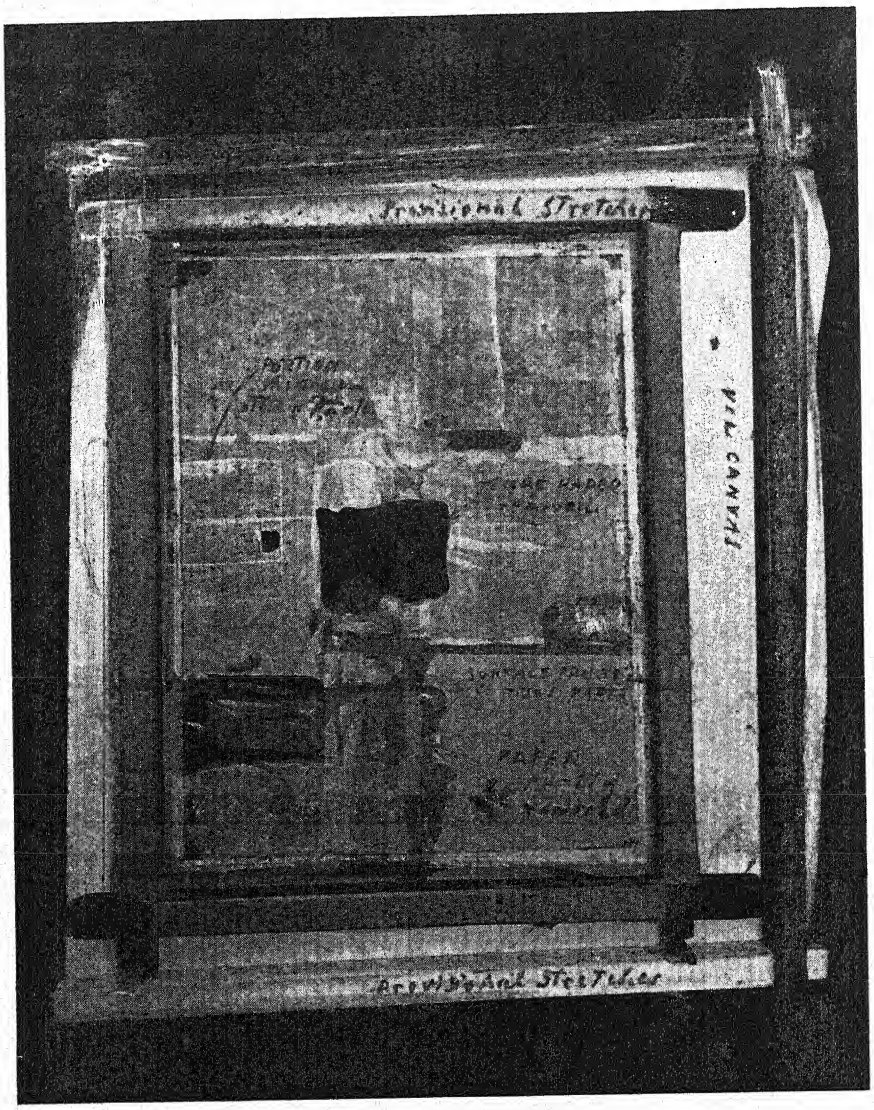
Both of these adhesives can be varied considerably by the addition of plasticisers or hardening substances in different proportions. They can even be combined to form a composite adhesive.

The type of adhesive must, of course, be chosen and adapted for each special case. There is, as yet, no universal adhesive that would suit every category of picture. (Below will be found a detailed description of the various mixtures, with an indication of their respective values.) A word of warning is necessary regarding the use of any adhesive which contains a large proportion of oil, owing to the danger of staining and yellowing the ground and even the paint.

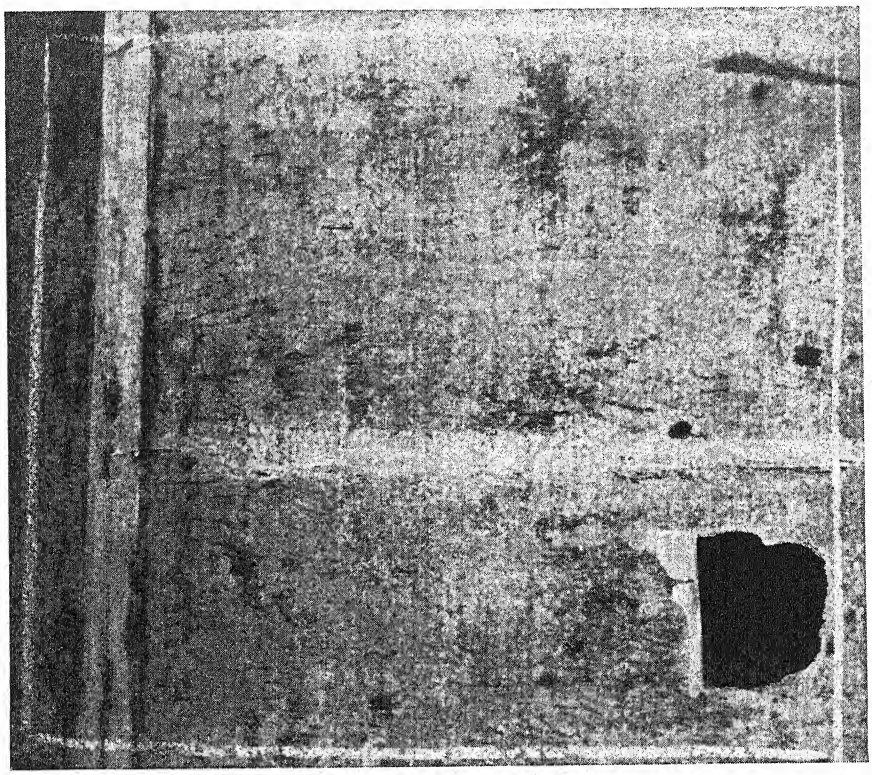
The discovery of polymerised vinyl acetate—a synthetic resin—has given promising results, but owing to its relatively recent use it cannot yet be generally recommended. Its chief advantage is that it is colourless.

Glue Adhesives.

200. — Many adhesives containing some kind of glue as the main ingredient



55. RE-LINING OF AN XVIIITH CENTURY PORTRAIT. THE NEW CANVAS IS STRETCHED ON A TEMPORARY AND LARGER FRAME, AND THE ORIGINAL FIXED TO A SMALLER TEMPORARY FRAME PLACED OVER IT AS THE IRONING IS DONE CHIEFLY FROM THE FRONT (ON A FELT MAT). THE PHOTOGRAPH SHOWS THE OBVERSE OF THE PICTURE, WITH THE PROTECTIVE PAPER. THE RECTANGLE SURROUNDED BY A WHITE LINE, ON THE LEFT, AND INDICATED BY AN ARROW, IS REPRODUCED TO A LARGER SCALE IN THE NEXT FIGURE.



56. RELINING OF AN XVIIITH CENTURY PORTRAIT. DETAIL (ENLARGED) OF THE PREVIOUS FIGURE. THE SURFACE PROTECTION OF TISSUE PAPER SHOWS, AFTER THE OPERATION, DARK MARKS CORRESPONDING TO THE SPOTS WHERE THE ADHESIVE HAS PENETRATED THROUGH THE CRACKLES.

have, from the earliest times, been used with more or less success. We shall confine ourselves to describing in detail only those that have best stood the test of time and proved their value under scientific examination.

Though adhesives of this type are being more and more discarded for relining work, it will not be inappropriate to deal with them here, because they cannot be entirely dispensed with in special cases and because there are many instances of successful glue relinings to be seen in picture galleries.

It must be emphasised, however, that a badly executed glue relining is far

more dangerous for a picture than an unsuccessful wax lining. The reasons for this become evident when we examine the principal drawbacks.

Disadvantages of Glue Relining.

201. — When a glue adhesive has been used, the relining can rarely be removed without damaging the paint layer, because the canvases must be moistened and scraped.

The steam which is necessarily produced during the process of ironing is apt to affect the ground, and even the actual paint in the case of size or tempera paintings.

Mould and other maladies of this kind may attack the paint layer.

Changes in the degree of atmospheric humidity cause appreciable expansion and contraction of the glue, which are likely to affect all the layers of the picture.

The slightest fault committed in the course of the operation (uneven distribution of the adhesive mixture, etc.) cannot be remedied, for once the adhesive has dried and hardened, it cannot be remelted or softened.

On the whole, all adhesives containing any considerable proportion of water are definitely dangerous to certain types of paintings, for example those of the XIXth century.

Attenuation of these Disadvantages.

202. — All the disadvantages indicated above can, to a certain extent, be attenuated by the addition of appropriate substances. First of all, a *plasticiser* must be added to the glue; Venice turpentine has so far proved very useful for this purpose. Glycerin, on the other hand, would merely increase the susceptibility of the picture to the effects of moisture.

Secondly, the addition of some ingredient is necessary to facilitate the dissolving of the adhesive when the relining has to be removed. Flour paste is very suitable for this purpose.

Finally, a lasting *disinfectant* should be incorporated to prevent mould and rotting of the canvas; a small quantity of sodium-fluoride is to be recommended; it is a non-volatile substance and does not appreciably affect the adhesive properties of the mixture used.

A fairly large proportion of Venice turpentine is needed to counteract the powerful *traction* of the glue.

Recipes.

203. — The following recipe is given as a rough indication of what should be used for a preparation to be employed for an average picture; it may be varied considerably to meet the requirements of individual cases.

Glue	3	parts	by volume
Venice turpentine	1	—	—
Flour	½ to 1		—
Disinfectant	¼	—	—

For the purposes of the above formula, the glue and the flour are prepared with warm water to the consistency of the Venice turpentine and the quantities are then measured as required for the relining mixture, the disinfectant being stirred in last.

A mixture of flour and Venice turpentine without glue is also commonly used, but the adhesive thus obtained is probably not so lasting.

These composite adhesives should be subjected to scientific tests.

Advantages of Glue and Disadvantages of Wax.

204. — The chief advantage of the glue mixture lies in its strong adhesive power—an important property in the case of very large canvases (especially in hot climates), which would be too heavy for a wax adhesive, or when relining pictures that have developed bumps or depressions in the paint layer and in such a high state of tension that it would be impossible to reduce and maintain them in position by using a weaker adhesive.

This point is also important when one has the intention of cleaning the picture, after relining, with a solvent that would tend to dissolve a wax adhesive. Even weak solvents, such as turpentine, would penetrate through the cracks, thereby softening the wax and the resin (alcohol would not attack the wax but the resin), and again loosen the particles of paint which the relining was primarily destined to save.

Another advantage of a glue adhesive is that it interferes but very little with the optical properties of most primings (reflecting power). Wax, on the other hand, would slightly reduce the reflecting power of a more or less absorbent white priming, and thus darken somewhat a transparent painting executed on such a ground.

In the case of an oil painting, the wax which penetrates into the paint layer

or which even spreads over its surface through the crackles would reduce the depth (transparency) of the colours a little and thus make the dark tones appear a shade lighter and duller. In an old master—a Rembrandt or a Titian, for example—this loss of transparency would alter the effect originally intended by the artist. Moreover, as mentioned above, a varnish applied to a painting in such a condition would not retain its transparency and would tend to crackle.

Remedies.

205. — These drawbacks can, however, be met by adding a little resin, as a hardening ingredient, to the wax. Rosin (colophony) is generally used for this purpose and has so far proved very successful. In inferior grades, it has the disadvantage of being rather dark, so that for bright paintings, or for pictures where the white priming plays an important part, none but the clearest quality should be used.

The combination of wax and resin gives too brittle a composition and some kind of balsam has to be added to ensure sufficient elasticity. For this purpose, Venitian turpentine is the most frequently used, but gum elemi or Canada balsam would probably give equally good results.

The exact proportion of the ingredients does not seem to be of any great importance and may be modified to suit individual cases (account being taken of the melting-point, etc.), as has been shown by scientific tests.

The following may be recommended as an average recipe:

Beeswax	5	parts	by weight
Rosin	2-4	—	—
Venetian turpentine.	1	—	—

Owing to its very low adhesive power, paraffin is unsuitable as an ingredient of a mixture to be used for relining purposes; it may, however, be used as a diluent for wax resin mixtures, particularly for reducing the melting-point of the mixture. Paraffin facilitates the even distribution of the adhesive. The addition of a small quantity of essence of turpentine is harmless and would serve the same purpose.

Wax glue emulsions.

206. — No systematic study, based on the results of scientific tests, has as yet been published on wax glue emulsions; in practice, however, these preparations

have often given satisfaction, but we cannot, for the time being, recommend any particular formula.

Generally speaking, most of the glue mixtures can be emulsified with the wax compositions, but there can be no doubt that the simpler the formula the better. If glue is added to a wax mixture, the resin should be omitted, for the glue takes its place as the hardening factor.

It is not easy to prepare an emulsion that would not split up again under the heat of the iron. All the ingredients must be fairly thick and kept warm, but not hot, during the mixing. The order in which the different substances are added is also important.

Other Emulsions.

207. — If the wax, thinned slightly with turpentine, is first saponified by the addition of a little ammonium carbonate dissolved in water, it is more easily incorporated with the glue. The perfect emulsion is that which absorbs water as well as turpentine as a diluent. The quantity of water added should, of course, be reduced to a minimum.

Whatever proportion may be adopted, the emulsion should be tried out on a small square of canvas and tested for adhesive power and elasticity. It must also be ascertained that it does not dry too white and so disturb the appearance of the picture wherever the adhesive has penetrated to the surface. It must also be borne in mind that an emulsion sets and hardens during the process of ironing; the latter operation therefore demands a certain rapidity and skill.

The following substances may be recommended for the preparation of an emulsion: wax (saponified), Venetian turpentine, and glue.

When cold, all adhesives should form an elastic substance but just hard enough to be scarcely marked by the impression of a finger-nail.

Fixing the Canvas to the Stretcher.

Stretching.

208. — With the exception of small pictures, all paintings that are to be relined should be stretched on a frame measuring about 5 cms. more than the painting along all four sides. The four borders of the canvas are fixed to the frame by means of strips of strong packing paper stuck down with glue. When the glue is dry, the paper is moistened and, as it dries, automatically stretches the canvas.

Surface Protection.

209. — In order to protect the surface of the painting against the detrimental effect of moisture in the adhesive, or of the water used to damp the back for dissolving the priming, all pictures should first be covered with a thick layer of mastic oil-varnish, which is removed at the end of the operation. The varnish should be thoroughly dry before the paper is applied. In cases where the paint is not detached from the ground and where the picture is being relined as a precautionary measure, or because of small tears or similar damage, there will be no necessity to stick the paper to the painting; it may simply be laid over it as an insulation from the felt and can thus be lifted from time to time in order to check the progress of the operation.

In all other cases, a sheet of tissue paper should be pasted over the paint layer. Whenever a painting is to be subjected to a treatment that involves some kind of concussion or vibration, such as the removal of an old support by scraping or tearing, the paint film should first be protected by one or two sheets of tissue paper, a piece of muslin and, finally, several layers of paper, all of which are stuck down with diluted glue mixed with glycerine. The adhesive used for this purpose should be easily removable, if possible dry, or at least with a minimum of moisture. It should exert but slight traction; strong glues and mixtures containing casein are therefore unsuitable.

Flour paste has frequently been recommended for this purpose, but it should not be used without the addition of a little Venice turpentine; otherwise it often becomes brittle and may spring off in places, tearing particles of paint away before they are secured. A safer adhesive is a solution of gelatine or gum arabic with a few drops of glycerin. These solutions have the advantage of being more rapidly removable. In any case, the type of adhesive employed should be specially adapted to suit the painting to be treated and should always be tested beforehand on samples or on the edge of the picture.

Felt or other Bedding.

210. — In order to prevent the surface texture, impasto brushwork, etc., from being flattened down by the ironing, the painting, with its protective covering of paper, should be laid on a bedding of felt. The thickness of the felt will vary according to the depth of the protuberant portions of the paint layer.

For the treatment of extreme cases—a Van Gogh, for example—felt is not sufficient and a bedding of finely sifted sawdust must be used instead; the

sawdust should be kept in place by strips of wood nailed to the edges of the table and pressed, with a box, so as to form an even and compact bed.

A suitable insulating material, which may be used instead of paper, is tinfoil; a sheet of this adjusts itself to all surface irregularities under the pressure of the brush.

Ironing table.

211. — The ideal working table for relining and similar operations is a thick slab of slate, kept at the suitable temperature (about 50-60° C.) by an adjustable electrical heating device underneath. This makes it possible to ensure a uniform melting through of the adhesive to the surface of the paint, thus dispensing with the ironing of the front (on the felt bedding), which is often necessary to obtain thorough adhesion. A more complicated equipment is needed in the case of a sawdust bedding. The table must, of course, be heated to a higher temperature when dealing with special cases and should be fitted with thick felt mats, etc.

The Iron.

212. — An excellent type of iron has been designed for relining, but an ordinary tailor's iron may be used, provided that it is fitted with an adjustable resistance between the plug and the iron to maintain a steady temperature. The iron should also be fitted with a thermometer, if not a thermostat, by which the amount of heat can be controlled.

It should be pointed out that to check the temperature of the insulating material (felt or paper) is not directly conclusive, because the paint layer itself can accumulate far more heat than the insulating layer. This simple remark is sufficient to indicate that considerable experience, concentration and patience are essential for this process of ironing.

Cleaning of the Old Canvas.

213. — When a painting is removed from its original stretcher, the dirt on the back of the canvas should be cleaned off with a fairly stiff brush. Labels of any interest should be carefully soaked off and preserved, but never stuck on to the new canvas as this would cause it to bulge; they can be stuck on to the stretcher. If the old stretcher is sufficiently well preserved, it is preferable not

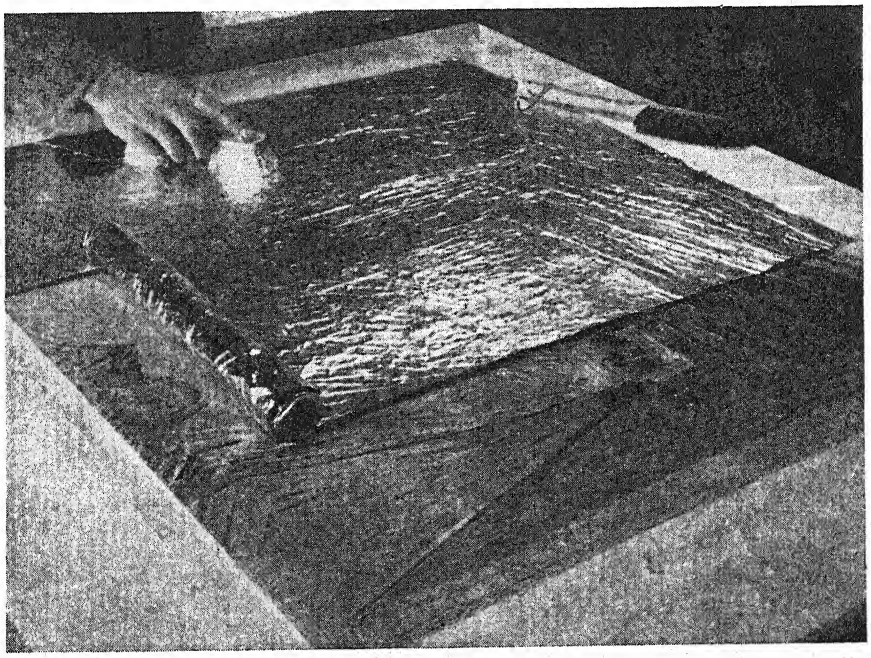
57. RE-LINING OF A VAN GOGH. PREPARATION OF THE SAWDUST BED ON WHICH THE PAINTING IS LAID FACE DOWNWARDS AND WHICH PREVENTS THE CRUSHING OF THE IMPASTATION DURING THE OPERATION.

to discard it for a new one. If it is made without wedges, it can sometimes be converted to receive them.

Lettering and other particulars inscribed directly on the canvas should be photographed.

The edges of the original canvas, folded back over and nailed to the stretcher should always be retained. Until they have been thoroughly cleaned, it is impossible to know whether or not they carry a portion of the paint layer and, moreover, they alone permit of relining the picture satisfactorily.

The original canvas is then carefully cleaned (filed) to give it an even surface and to make it more permeable to the adhesive, at the same time neutralising its tractive power. These operations should never be carried out without laying the painting on a felt mat and the cleaning should be completed by a

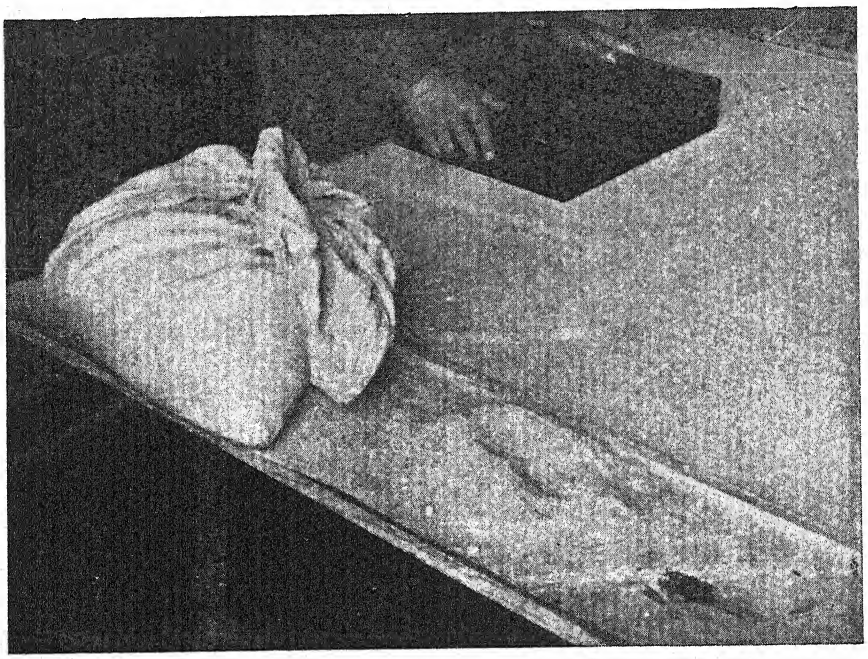


58. THE EDGES OF THE PAINTING ARE HELD BY STRIPS OF STRONG PAPER. THE SURFACE IS PROTECTED BY SHEETS OF THIN PAPER OR TINFOIL, PRESSED DOWN WITH A BRUSH TO ENSURE ADHESION TO THE CONTOURS OF THE SURFACE.

careful polishing with pumice stone or sand paper to ensure proper adhesion.

Application of the New Canvas.

214. — The new canvas should be smooth and of fairly heavy quality, but not necessarily of the same quality as the original support. It should be stretched on a stretcher the inside measurements of which are about 3 cms. more than the painting; it should be unprimed but, for normal cases, thinly sized. All irregularities, which would necessarily make an impression on the original canvas during the process of ironing, should be filed off. The new canvas should first be soaked with the adhesive, and to avoid a patchy appearance care must be taken to ensure that the adhesive is absorbed evenly.



59. THE SAWDUST BED IS LEVELLED BY MEANS OF A BOX.

In certain cases, it may be preferable to spread the adhesive fairly thinly on the old as well as the new canvas, both being laid on the warm table.

The successive stages of the operation are briefly as follows: on the warm slate slab, we have first of all the felt mat (or the bedding of sawdust), next the sheet of insulating paper (which, in the majority of cases, is stuck on to the surface of the picture), and, lastly, the painting, face downwards, fixed to its stretcher by strips of adhesive paper. The back of the picture is then given a thin coating of adhesive. The new canvas, also smeared with adhesive and fixed to its stretcher (slightly smaller than that of the old canvas) is now laid (stretcher upwards) on the back of the original support.

The ironing is, as a rule, done from behind, starting in the middle and working in a radial direction to press all air pockets towards the edges. This requires considerable experience and skill: if the iron is too hot or moved too slowly, too much of the adhesive will be melted out, or may even be burnt; on

the other hand, if the iron is not hot enough or is moved too quickly, the quantity of adhesive melted will be insufficient and will, therefore, be unevenly distributed. The wax resin adhesive does not, of course, stick while it is still hot; the iron must therefore be cooled for the next stage of the operation, to ensure adhesion between the two canvases by pressure.

When paintings that have a rough texture or a high impasto are ironed from the front, no felt or other soft bedding should be placed beneath the new canvas, because the parts of the paint layer in relief would be pressed down into the bedding.

Ironing—or at least warming from the front—should be continued until the melting-point of the adhesive is reached, if it is wished to make the latter penetrate to the surface of the paint layer (to secure loose particles, etc.).

Pressing.

215. — When dealing with particularly tenacious cases of tension, waving, bulging, crackle, etc., it is sometimes necessary, after the relining operation, to press the two canvases together in a special appliance composed of boards and carpenter's screws. In extreme cases, a second canvas has to be stuck on to the first relining canvas; in other words, the whole operation has to be repeated.

Occasionally, certain cracks which have not been sufficiently reduced during the process of relining will have to be ironed again separately with a small iron or with the small spatula used for the treatment of blisters. (See Chapter XIII).

III. Transfer.

Cases needing Transfer.

216. — The indiscriminate use of the expression "relining" has led the uninitiated to believe that whenever a picture is "relined" the original canvas is removed. As already mentioned, in the majority of cases, the old canvas is retained and the operation consists simply in reinforcing it by a new canvas, that is to say, it is "lined". The problem is quite different with a panel painting that is threatened with deterioration on account of the condition of the wood (rot, worm-holes, etc. See Chapter XVI).

It is, however, easy to disinfect a disintegrated canvas and once it has been properly lined it will no longer constitute a danger to the painting.

But when the deterioration has reached the priming, the picture will have to be transferred to a new support. A transfer is also necessary in the two following cases: when the paint has become brittle or has a tendency to flake away from the ground, which, in turn, detaches itself from the canvas; or when the priming is so thick that the adhesive would not penetrate it sufficiently to secure the loose particles of paint. In this latter case, the thickness of the priming must also be reduced by scraping, after removal of the canvas.

Choice of a New Support.

217. — On the whole, the procedure followed for a transfer is the same as that adopted for panel paintings. It should be stressed, however, that the transfer of a painting from wood to canvas—a common operation in the XIXth century—is no longer practised today. Canvas was formerly, and rightly, regarded as the safer support, but in practically every case the character of the painting, transferred to canvas, was altered: the texture penetrated more or less into the paint layer; the painting assumed a certain rectilinear or misleading aspect on account of the new crackles that appeared.

The main objection to wood as a new support (expansion, contraction, warping) is met by the modern use of plywood or artificial panels (see Chapter XVI); moreover, effective means are now available for protecting the wood against insects, growths and other deteriorations.

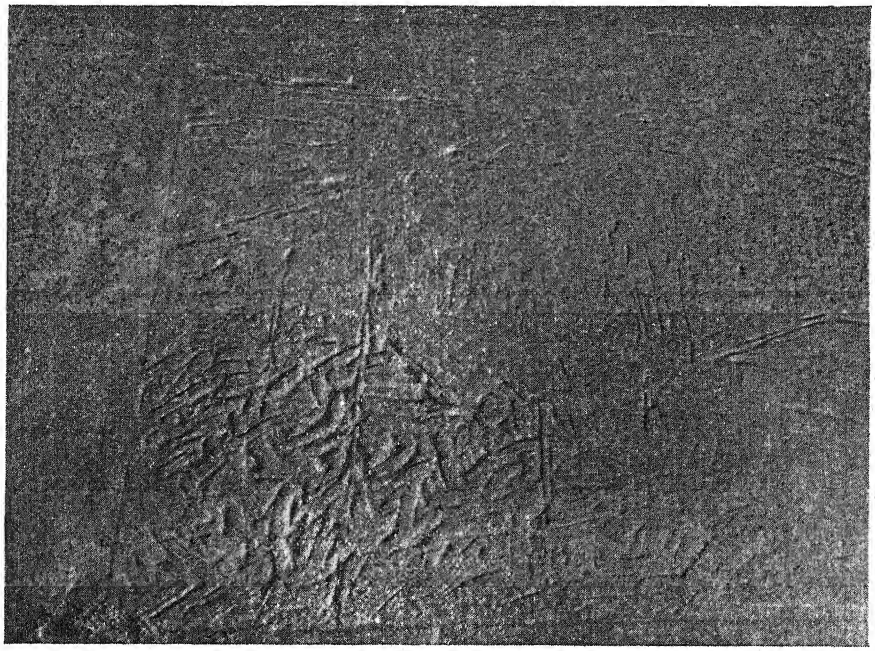
It is therefore possible to establish the principle that, in order to preserve the original character of a painting, it should always be transferred to a support of the same material, that is, from canvas to canvas, or from wood to wood.

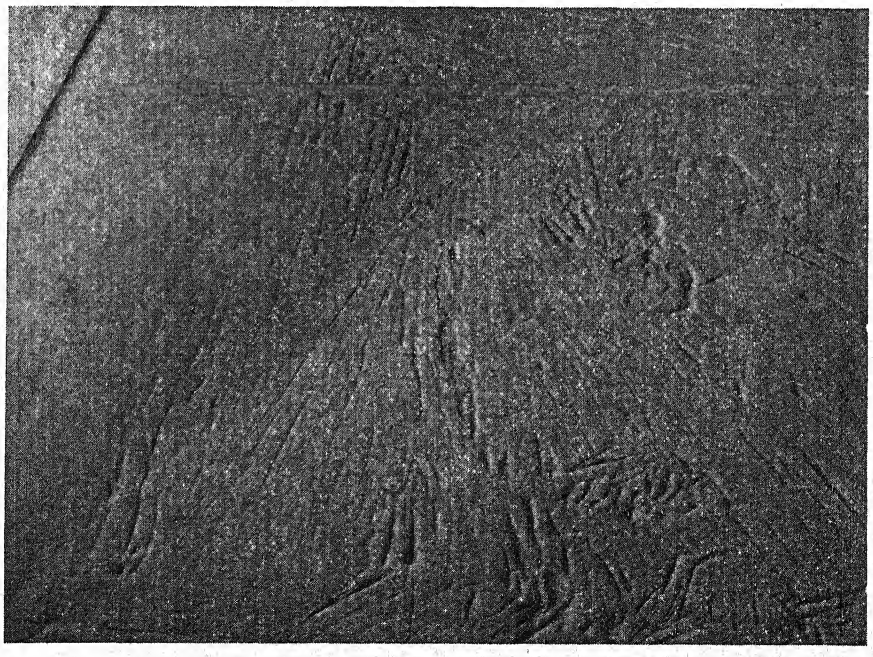
A transfer is, of course, a more complicated operation than a simple relining, but it is far less dangerous than the uninitiated generally believe. The experienced restorer can execute a transfer without sacrificing the smallest particle of the original paint. He will, however, often ask the owner to claim no compensation in the event of a slight loss of paint.

Surface Protection.

218. — It is the method usually adopted for protecting the surface of a painting that makes the process such a safe one.

Paper is stuck on to the surface of the painting, as for a lining operation, but for a transfer the paper is always reinforced; in the case of a smooth picture, several sheets of paper or a single sheet of cardboard are used; if the picture has





60-61. IMPRESSIONS LEFT IN THE SAWDUST BED BY BRUSH-STROKES AND IMPASTATION.

DIAGRAM SHOWING THE SCHEME OF RELINING

1. Before lining; section of the canvas and stretcher, face downwards.

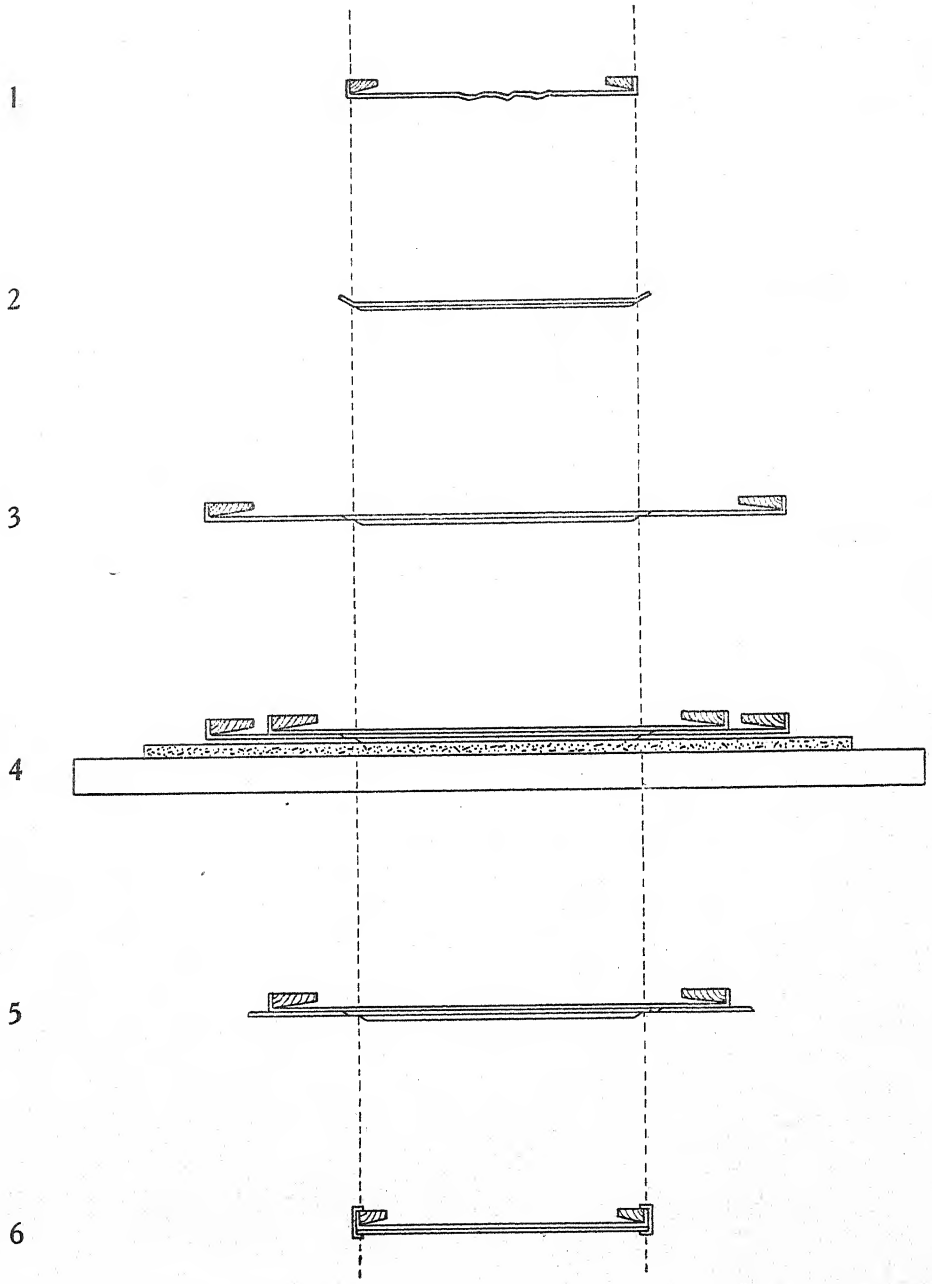
2. Protective paper attached to fix the paint layer; the picture unmounted from its stretcher.

3. Paper strips attached around the picture so that it may be stretched on a larger frame.

4. The process of lining using the hot table. A felt pad is placed between the picture and the table and the new canvas, mounted on its own provisional stretcher, is attached to the back of the picture. Reading downwards, the section shows: the frame with the new canvas; the frame with the picture bordered with paper strips; the sheet of protective paper applied to the surface of the painting; the felt pad, and the hot table.

5. After the adhesive has penetrated uniformly and been allowed to cool somewhat, the paper strips are cut away.

6. Final stage: the relining canvas is stretched after cutting away excess; the protective paper is removed from the picture and the edges are consolidated by covering with adhesive tape or strips of paper.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a rough surface texture, a layer of wax (the melting-point of which is higher than that of the adhesive), gesso, or *papier maché* is spread between the sheets of paper. The protective covering of paper should dry on the picture under pressure, so that one may be absolutely certain that it adheres perfectly everywhere and that no air pockets remain.

Removal of the Support.

219. — When the surface protection is dry, the picture is laid, face downwards, on the bench and carefully fastened to it by some device such as carpenter's screws.

The canvas is then gradually removed, either by filing or by cautious damping; sometimes a mild acid solution is used. Very often, the threads of the canvas can be pulled out once the priming has thus been partly dissolved.

Cardboard or paper supports can be removed in a similar way.

A wood support is first planed and finally chipped away with fine chisels; the last layer can often be pulled off when the priming is sufficiently moist.

One should never attempt to remove large areas of canvas or priming in one operation; one must proceed in short stages, working in small squares, care being taken to secure the rest of the picture by screwing boards over it.

Removal of the Ground.

220. — A deteriorated gesso or other size priming—more frequently found on panels than on canvas—should be gradually removed by further filing or by rubbing with a damp swab.

Oil primings rarely disintegrate, but if it should be found necessary to remove such a layer it must be filed off dry or carefully cleaned off like an overpaint.

In some cases, a thin layer of priming may be allowed to remain if found intact, or even thicker layers if they can stand a treatment by impregnation.

Photographic Record.

221. — When all the priming has been removed and the actual paint appears at the back, this should be photographed and described in detail; valuable information on the technique of the particular master or school will often be recorded in this way.

Application of the New Ground.

222. — The next stage of the work—the replacing of the old priming by a new ground—requires special skill and a thorough knowledge of the structure of paintings of all schools. The new ground must have exactly the same optical properties as the original priming, identical in colour or whiteness. In this connection, allowance should be made for the darkening of the picture with age when re-establishing the original tone of the priming. Moreover, the new ground should, as nearly as possible, have the same reflecting (or refractive) power, that is to say, it should be just as dull or as shiny as the original priming.

This new priming can rarely be applied in one layer but has to be carefully and progressively built up. If it is possible to make it more inert, more elastic and more adhesive than the old priming, without appreciably altering the optical effect, the result will be all the more satisfactory. As a rule, it is preferable to use a mixture containing casein. If necessary, a piece of muslin may be inserted before the new ground is applied.

The composition, preparation and application of the priming demand quite a special technique, a detailed description of which would go beyond the limits of this study. Indeed, to carry out this operation successfully, it is necessary, in each individual case, to conform to the technique of the painting to be treated, and reference should be made to the works dealing with the craft of the old masters.

Adhesives.

223. — In some cases, a special adhesive, such as a lining mixture, can be ironed into the paint layer from behind, when the paint layer has been rid of the priming; if this method is adopted, an intermediate coating of size or emulsion must be applied to ensure perfect adhesion between the paint layer and the ground.

Similarly, it will, in some instances, be necessary to apply a separate coat of size or some other adhesive to the new support before this is laid and pressed on to the priming.

Pressing must, in most cases, be done with the aid of slabs of slate or metal plates and nearly always at a certain temperature; very often arrangements must be made to raise the temperature at the front of the painting as well as the back of the new support. The temperature of these slabs or plates is of primary importance for the success of the whole operation.

Removal of the Surface Protection.

224. — When all the layers of priming and adhesive are thoroughly dry, the picture may be laid face upwards and the surface protection removed in the manner described in the section on relining.

CHAPTER XVI

MALADIES AND TREATMENT OF WOODEN SUPPORTS

A. — DESTRUCTION OF WOOD PARASITES.

It is necessary to consider the two main types of attack: *insect attack* and *fungoid attack*, and as these require to be dealt with very differently, the importance of correct diagnosis will be obvious.

Insect Attack.

225. — Insect attack leads to the formation of tunnels, galleries and round holes like shot-holes and, by tapping the surface, clean pulverised wood may be extracted which is the material that has been excreted by the insects. The particles of this powder are generally of rounded shape, rather difficult to distinguish macroscopically from insect eggs. The wood is usually very dry.

Fungoid Attack.

226. — Fungoid growths are to be looked for especially along joints in the wood to which water may at one time have had access. In advanced cases of so-called "dry rot", the wood becomes soft and spongy and cracks may appear across the grain; the wood may be either damp or quite dry and often the surface is quite sound whilst the underlying wood is shrunk and decayed. The condition of the wood can be tested by pressing gently on the painted surface and tapping with a knife.

Insect attack is treated by fumigation, the holes being stopped afterwards if so desired. Fungoid attack, in its advanced condition at least, requires a major operation, namely the removal of all decayed wood and the only alternative is the transference of the painting to another panel or canvas. (See *Transfer*.)

Treatment of " Worm-eaten " Panels.

227. — Of the many sterilising agents which are available, the best are gases or liquids having a high vapour pressure and thus able to penetrate easily to

the depths of the insect-holes. The primary consideration is to determine what substances can be used without damaging the various materials employed in the preparation of the priming and paint.

The following are considered dangerous, that is, they either cause immediate damage or may, in time, be deleterious and should never be employed: all acids and alkalis and aqueous solutions of whatever nature; halogen-containing compounds, organic or inorganic, such as carbon tetrachloride or dichlorobenzene; all solvents for oil and varnish and agents which may cause paint to soften, such as thymol. Hydrogen cyanide gas has been used effectively against attacks by wood-beetles, but it is a virulent poison and should be employed only by a qualified specialist.

The results obtained with carbon-monoxide have proved disappointing.

Carbon-disulphide, a highly volatile liquid, has been found a very effective fumigant, convenient in use and without any apparent action on painting materials when the following precautions are observed:

Pure carbon-disulphide only must be employed. — The substance must be fresh. It should be kept in a cool place, away from sunlight, in a ruby glass bottle. — As it is highly inflammable, it must be used only where there are no naked lights and smoking must be prohibited in any rooms where carbon-disulphide vapour is present.

Fumigation by Carbon-disulphide.

228. — A panel should be fumigated as soon as convenient after the discovery of evidence of active insect life. A large box, about 2 feet high, constructed of deal, about 1 inch thick, is lined with sheets of varnished paper or in some other way to render it airtight. A board of similar wood acts as a lid which may be slid off as required; the lid should be lined in the same manner as the box and if a strip of thin felt is glued along the edge of the box the weight of the lid upon it will form a joint which is sufficiently gas-tight. The painted panel, frame, etc. to be fumigated are supported, face upwards, inside the box, say 4 inches from the bottom, and saucers of carbon-disulphide are placed inside the box, beneath the object to be fumigated. The lid is immediately replaced.

The total quantity of carbon-disulphide must not be less than 1 ounce per cubic foot capacity. The vapour soon saturates the air in the box and enters the pores of the wood.

62. PANEL WITH THE BACK SAWN OFF AND THE OUTER SURFACE OF WHICH SHOWED NO SIGNS OF DETERIORATION: INSECTS HAD BORED THEIR WAY IN FROM THE EDGES.

After the lapse of four days, the lid is removed and the saucers replenished with a similar quantity of insecticide. The lid is replaced and kept in position for at least a fortnight. By this means, all grubs and full-grown insects are destroyed, but not necessarily all eggs, although such treatment is often sufficient to effect a permanent cure. It is obvious that a fumigated panel must be scrutinised later on during the vulnerable period when the eggs are commonly hatched out, in order to ensure that no life persists; some knowledge of the life-history of the parasite is therefore necessary.

In the case of the ordinary furniture beetle, which is the chief offender, this inspection and any further fumigation which may be necessary should take place in May or August. After fumigation of a panel, it is advisable to fill the "worm"-holes with wax, as this facilitates subsequent examination.

B. — REPAIRS, CONSOLIDATION, TRANSFER

" Movement " of Wood.

229. — Of the various materials used as supports for paintings, wood is the most susceptible to atmospheric influences. The general rules of conservation should therefore be strictly observed when one is dealing with works executed on wood.

It must be remembered, however, that even under the most favourable conditions a wooden panel is never inert, that is to say, it is continually expanding or contracting according to the degree of atmospheric humidity. Healthy panels, therefore, are also constantly subject to deteriorations of the paint layer on account of the variations that take place in this surrounding atmosphere. Consequently, paintings executed on wood should, in particular, be kept under constant observation.

When considering the various forms of deterioration that manifest themselves, one must first of all ascertain whether they are in the acute stage and caused by temporary influences, or whether they are of a chronic nature and due to permanent causes. According as the deterioration falls within the first or the second category, steps should be taken to eliminate the external or internal influences, as well as the *symptoms*, or, by resorting to more thorough treatment, the *diseases* which are inherent in the wood properly so called.

In this connection, the following fundamental rule is of capital importance: the free movement of the wood, which exerts itself across the grain, must not be hampered.

I. — Large cracks, crevices. — Cross-battening.

Causes of these deteriorations.

230. — Cracks and crevices, which must not be confused with crackles, may appear in the form of fissures which follow a straight line from one edge of the panel to the other. Such cases are almost invariably due to the breaking of the joint.

An accident of this kind may be caused by the fact that, owing to mildew, for example, the glue has lost its adhesive power. There may, however, be additional causes: the wood adjacent to the joint may have rotted or have become

worm-eaten; again, as the result of inappropriate treatment, the uniform movement of the wood may have been arrested. This latter phenomenon may be due to the addition of battening, to an over rigid fixing of the panel within its frame, etc.

Wavy cracks and crevices which do not spread right across a panel are frequently due to a wrong choice of wood; less often to the uneven planing of the surface, but nearly always to the injudicious addition of new elements, such as cross-battens glued to the back, the introduction of dovetailed joints, the wedging of cross-battens, etc. This latter point is dealt with in greater detail in the section on cradling (§ 235).

Preventive measures.

231. — As already stated, the direct fixing of any new part across the grain of the wood must be avoided. This fundamental principle may be supplemented by the rule that parts added and fixed in the direction of the grain must never be in a wood harder than that of the original panel.

Remedies.

232. — Whatever may be the defect that has developed, the operations contemplated should be entrusted only to specialists.

First of all, immediate steps should be taken to remove all the parts that have been added by injudicious and thoughtless treatment.

Before sticking the broken joints together, it may be necessary to harden the adjacent portions that have rotted by applying a coat of thin glue. This operation, however, needs to be very carefully carried out in order not to dissolve the priming. There is another danger to be guarded against: when, in the process of drying, the glue penetrates to the paint layer, the latter may sink into the galleries eaten away by insects and these areas of the picture will be marked by small depressions.

The next step is to stick strips of canvas along the crevice, or thin laths of wood, in the direction of the grain.

Cradling may be necessary to prevent a recurrence of this type of deterioration.

In extreme cases, the use of plywood boards has proved successful. (This operation is explained in §§ 216-224.)

II. Warping.

Causes.

233. — This form of deterioration is caused by the natural drying of the wood; distortion is more pronounced at the back than at the front of a picture, as the paint layer restrains the drying of the panel.

Remedies.

234. — A warped or distorted panel may be treated by applying a coat of good quality copal varnish to the back, edges and front. This should be undertaken only when the moisture content of the wood is at its minimum, for example in prolonged periods of cold weather and in a room that has been warmed for some time. Sizing, or the application of a piece of fabric or other material stuck to the frame and covering the back of the panel, is scarcely effective. The edges are sometimes protected by strips of adhesive tape.

Impregnation by various substances has, so far, not proved satisfactory. These substances also often alter the reflective qualities of the gesso priming when they penetrate to that depth, besides darkening the picture; in many cases the alteration in appearance develops unevenly in the form of darker patches.

The remedy consists in subjecting the panel, with all due precaution, to the action of moist air; the result obtained, however, is rarely permanent. Recourse should therefore be had to cradling and, in extreme cases, to the use of plywood or to a transfer operation.

Generally speaking, one should never attempt to straighten a distorted panel by forcible means; such treatment is apt to break it entirely or, at any rate, to crack the paint layer.

Cradling.

235. — Cradling or cross-battening will correct only the curvature or warping of a panel; the operation may be a remedy for blistering only in so far as the blisters are caused by the curving of the panel, which is seldom the case (see Chapter XIII for the *treatment of blistering*).

Cross-battening has long been regarded as the sole effective remedy for the distortion of wood panels, and even for other kinds of deterioration to which

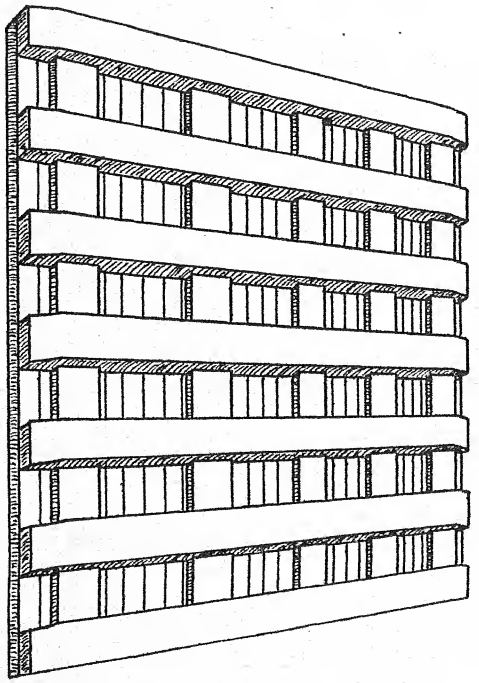
this type of painting is exposed. The method consists in fixing, to the back of the panel, a series of vertical battens equally spaced, over which are placed a similar series of horizontal battens. Needless to say, this framing can have no effect on the distortion of the panel or on the phenomena resulting therefrom. Moreover, if this system of battening is adapted to the panel without taking certain precautions to meet the "movement" of the wood, further deteriorations—sometimes more serious than those which it is sought to remedy—will develop, chiefly in the direction of the battens running parallel to the grain. We think it advisable, therefore, to go more into the details and application of this method.

It may be pointed out, incidentally, that the vertical battens can, in many cases, serve also for repairing the cracks or crevices of the panel.

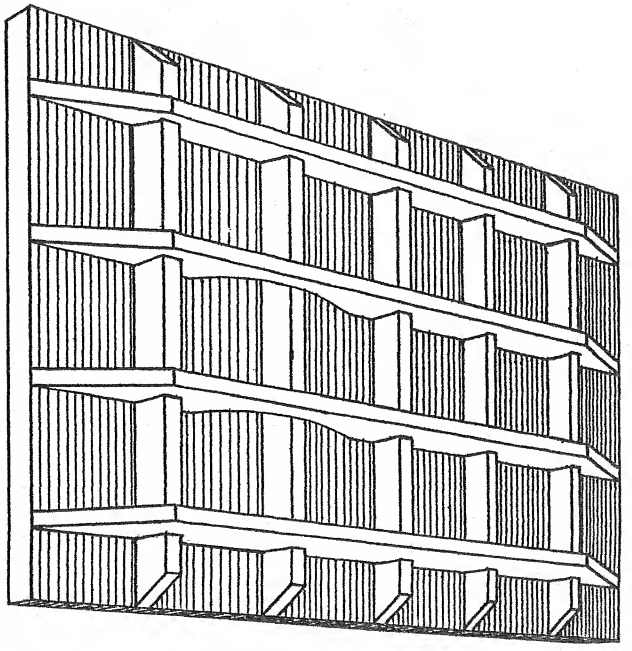
The reinforcing battens placed across the grain of the wood should always be free in relation to the vertical battens. The surfaces of the battens in contact one with the other and with the panel should be rubbed over with graphite to prevent any seizing and to allow free play of all the parts of the framing as the wood expands or contracts. The horizontal battens must, at no point, be fixed to the panel, otherwise there is a danger that the panel will split. If the tendency of the panel to shrink is stronger than its resistance, the mere jamming of the transverse battens may be sufficient to cause damage (crevices, splitting). It is often necessary to reduce the thickness of the panel, by appropriate planing, in order to diminish its tendency to shrink. In no case, however, must the panel be weakened to such an extent as to expose it to the risk of splitting.

Disadvantages of Cradling.

236. — It frequently happens that panels which are too thin or too weak, or which have a natural tendency to develop crevices, break after having been cradled. Accidents of this kind occur not only as a result of the jamming of the cross-battens, but also because the longitudinal battens—especially if they are made from wood that is not sufficiently seasoned or too dry—exert a strain, as they dry, on that part of the panel to which they are glued, causing it to separate from the adjoining parts that are not reinforced with battens. Another drawback of cradling is that the longitudinal battens, particularly if they are applied to a thin panel, cause deep undulations to form on the front surface.



CRADLING WITH BATTENS FLAT



CRADLING WITH BATTENS ON EDGE

Advantages of Cradling assembled on edge.

237. — The disadvantages referred to above are largely attenuated by cradling assembled on edge; this method is more effective in counteracting shrinkage and covers a smaller area of the original back of the panel. The principle underlying this new method of cradling consists in the use of a smaller quantity of new wood and in taking the maximum advantage of the resistance offered by the battens to the warping and distortion of the original panel. Instead of laying the battens flat, they are placed on edge; the cradling assembled in this way is infinitely narrower and lighter, while, from the point of view of efficiency, its resistance is very considerably increased, as will be seen from the following figures:

1) A batten 8×20 mm. in section, on edge, has a resistance 35% greater than that of a batten of the same thickness but twice as wide, laid flat.

2) When they are of the same sectional dimensions, the batten laid on edge is two and a half times more effective than a batten laid flat. Thus, sixteen battens laid flat can be replaced by ten of the same dimensions but placed on edge.

3) To obtain the same resistance to warping with the same quantity of wood, only 25% of the panel need be covered by battens placed on edge, as compared with 62% if the battens are laid flat. The area of the back of the original panel which remains visible when this new method is adopted is therefore much greater; this advantage is particularly important where the back of the panel bears inscriptions or seals.

Precautions and choice of material.

238. — A few general observations should here be added regarding the operations described above. The glueing of a thick board to the back of a panel is dangerous, even if it follows the grain, for owing to the different coefficients of expansion of the old and the new wood, cracks frequently develop in the original panel.

The *new elements* should always be of the same material as the old panel, and preferably softer. It is dangerous to glue the frames, as this is likely to cause fissures in the panel.

Adhesive : The best adhesive is still joiner's glue (skin glue or rabbit glue), since its coefficient of expansion approximates the closest to that of the wood.

III. Blisters, flaking of the paint and ground. Plywood and Transfer.

Causes.

239. — The causes of these deteriorations—the most frequently met with in paintings executed on wood—are generally: drying and shrinkage of the panel; excessive movement of the wood due to heat, continuous draught, or to rot, insect attack, etc. Sometimes, cavities appear beneath the priming, where insects have eaten channels away along the surface of the wood. (See also the chapter on damage to the ground layer).

Preventive measures.

240. — The preventive measures and remedies are the same as those indicated in §§ 233-236 and are subject to the same reservations. It should, moreover, be pointed out that the use of impregnation substances—which are practically ineffective—is dangerous for two reasons: 1) The diluent (vehicle) of hardening substances may dissolve or destroy the priming and the paint layer; this is chiefly true of size and cellulose; 2) The impregnation substance, if it reaches the priming, will affect its reflective properties. The result will be a darkening of the picture; in the areas where the substance comes into contact with material that has been rendered more permeable as the result of insect attack or some other deterioration, dark patches may develop. Lastly, the actual composition of the impregnating substance—acids, etc.—can cause damage.

It is accordingly advisable to avoid all substances containing oil; in this respect, waxes and resins are less harmful, while size and cellulose are the most harmless.

Impregnation with, or the application of, one or other of these substances can improve a painting, to a certain extent, only in mild cases of blistering due to the shrinking of the wood, but in extreme cases, treatment of this kind is of no real value.

Treatment.

241. — There are three different methods of treatment that can be employed according to the type of deterioration and the condition of the panel:

1) Action on the symptoms themselves (see Chapter XIII on the treatment of the paint layer).

2) Treatment of the causes inherent in the wood; we have already referred

to the means suggested for hardening wood and the dangers attending the adoption of such methods.

3) Radical elimination of all the causes of deterioration inherent in the wood, both those enumerated above and any other agent favourable to the disintegration of a panel and, hence, of the priming and paint layer. There are various means whereby these factors of deterioration can be eliminated.

Plywood.

242. — If the priming can still be saved, the panel can be backed with plywood. The operation consists in reducing the thickness of the original panel to, say, 1 or 2 mm. (according to the strength of the wood), which in most cases can be retained, and in replacing the portion of the panel thus removed by a sheet of plywood.

Precautions.

243. — The application of a plywood backing should not be resorted to unless every other remedy would be unsuccessful; moreover, the work should be entrusted only to experts specialising in this kind of treatment, for the choice of materials as well as the manner in which the operation is carried out, as will be seen later, is the condition *sine qua non* on which the success and permanent effect of the work depend. Compared with the method involving a complete transfer, this process has the great advantage of saving the priming, in so far as this is still intact, by retaining a thin layer of the original wood. Again, this thin layer makes it possible to reach the priming from the back, in cases where it needs consolidating, and also to restore its adhesive power; this operation is effected by impregnation with a suitable substance such as thin size.

Principle of the Process.

245. — The use of plywood, a comparatively recent innovation in the restoration of panel pictures, has been current for some time in cabinet-making and building construction. It dates from the time when mechanical tools became available for the production of wooden boards, of the required thinness but of fairly big dimensions, that could be assembled in several layers, the grain of each layer running at right angles to that of the adjoining layers.

The art of using plywood (which was evolved from veneering, known to the

Egyptians and very commonly practised in the XVIIIth century) is governed by two essential factors: the nature of the wood employed and the thickness of the sheets. We do not propose to discuss the technique of the assembling of these sheets in this manual, but it may be mentioned that firms specialising in this branch of manufacture have succeeded in perfecting the process to such an extent that they can now produce a material beyond reproach for the type of work with which we are here concerned. We shall therefore confine ourselves to describing the principle of the process.

When two pieces of wood of the same kind and of a certain thickness are assembled in such a way that the grain of each runs in the same direction, an excellent and lasting joint is obtained, since the two panels expand and contract also in the same direction and according to the same potential—this movement being practically negligible longitudinally but very pronounced transversally. But this does not prevent warping and distortion, which are inherent in a panel made from one piece of wood. If, on the other hand, these two panels are stuck together, with the grain at right angles, cleavage is bound to occur after a while, for the two parts are straining in opposite directions. These forces, however, will be strong or weak according to the thickness or thinness of the wood. There is, therefore, a thickness below which the force exerted by the wood is no longer sufficient to break the joint; this is the principle underlying the manufacture of plywood. The layers are stuck one to the other, in odd numbers (generally 3 or 5) and in such a way that the grain is alternately longitudinal and transversal. The hygrometric properties of these layers remain the same, but the composite panel thus formed undergoes no change in length or breadth, as the crossed fibres of the different sheets are held together by the adhesive. Longitudinally, the grain is so strong and stable that it completely counteracts any expansion or contraction of the adjacent grain breadthwise.

Irreversible Contraction of Wood.

246. — The question arises whether it is desirable to use a rigid material as a support for an old panel consisting of a single piece of wood. From the scientific standpoint, it is obvious that all hygroscopic materials continue to "move", whatever their nature and age may be. It has been observed, however, that wood, after shrinking fairly considerably after the felling of the tree, continues to expand and to contract according to the hygrometric variations of the surrounding atmosphere. Nevertheless, wood is subject to another movement

of distortion, which is continuous and exerted in the same direction, namely, the so-called irreversible contraction of wood. Certain indications go to prove that old wood panels have decreased in size, transversally in relation to the grain; for example, a circular panel will, with age, assume a shape approaching an ellipse, owing to the decrease in the diameter at right angles to the grain. Such a panel can be exposed to the action of moist air, but it will never resume its original circular shape: the contraction is permanent. — This phenomenon is confirmed by another observation that has been made: the painted surface of old panels often show the grain of the wood, which appears in relief through the paint layer. The surface of these panels must originally have been perfectly smooth and uniform. A more searching examination will reveal that it is the cells developed during the autumn growth—harder, smaller and with thick walls—which form the raised parts of the grain, while the intermediate depressions are formed by the cells produced in the spring—softer, bigger and with thin walls— which have shrunk and are therefore at a lower level. This contraction, which is here visible in the thickness of the wood, also occurs breadthwise, as proved by the phenomenon described above.

Scientific observations have been made of the duration of this irreversible contraction, according to the nature of the wood and the surroundings in which it was placed; experiments have also been carried out, from this same standpoint, in the artificial desiccation of wood. It will be sufficient, however, to have drawn attention to this peculiarity in order to stress the decisive part it plays in the rational treatment of wood used as a support for paintings.

Equilibrium of forces in the plywood and the panel.

247. — It is necessary to say a few words more before passing on to the technique of the process of restoration by means of plywood: the layers are assembled in such a way that each relies, for stability, on an intermediate layer, reciprocally in equilibrium, according to a symmetrical arrangement. Superimposing the whole of the original panel would introduce a new element that would break this symmetry and the resulting reaction would be the warping of the panel. The panel must, therefore, be regarded as a constituent part of the plywood and its strength must be equilibrated with that of one of the elements of the new backing. But, as we have already seen, the wood's firmness and tendency to "move" have decreased to a certain extent—with age and according to its nature and state of preservation; in the majority of cases, therefore, a thickness

of from 3 to 5 mm. will be sufficient, which would correspond to the strength of a sheet of plywood 1 to 1.5 mm. thick.

Operation.

248. — When planing down the back of the panel, all the necessary care should be taken to ensure that the paint layer and the priming are neither shaken nor subjected to any pressure likely to cause damage. The plywood back is applied when the desired thickness has been obtained, unless the condition of the panel necessitates previous treatment by impregnation. During these intermediate operations, the panel—reduced and weakened—should be supported to prevent distortion. The plywood panel should be fixed with one or other of the adhesives recommended in the section dealing with cradling.

The observations made in the various museums exhibiting panel paintings treated in this way point to the conclusion that this process constitutes a radical remedy for the most serious forms of deterioration to which these paintings are liable. But these results are satisfactory only in so far as the new material consists of judiciously selected woods that lend themselves to cutting up into thin sheets; where these sheets have been seasoned in conformity with appropriate methods and assembled in such a manner as to ensure their perfect cohesion, and where the material has been selected according to the nature of the wood from which the original panel was cut. The technique of the fixing of the new support also requires long practical experience of this special branch of the cabinet-maker's art. It is clear, therefore, that the neglecting of one or other of these precautions is apt to lead to accidents of the gravest character.

One of the principal objections raised against the use of plywood backings is that the original back of the panel is lost. Apart, however, from the fact that, in some instances, this operation is the sole means of saving works that have reached a certain degree of deterioration, it must be pointed out that the thickness of the old wood removed can often be stuck on to the new plywood backing. The old back may, indeed, bear inscriptions, marks or signs which it is advisable to preserve if it is thought that photographic records, which are always to be recommended in such cases, would not be sufficient. Moreover, curators have long been accustomed to the concealment of the original backs of old canvases, most of which have by now been relined.

Transfer. (See also Chapter XV.)

249. — The transfer properly so called of the paint layer and the replacement of the gesso priming should be envisaged only when the priming has deteriorated and disintegrated to such an extent that no other remedy can save it.

The transfer of the painting to a new panel cut from the solid is not to be recommended, for this new element would, sooner or later, be subject to the same deteriorations as the original wood. The fairly recent method of transferring a painting to composition boards has proved satisfactory.

Generally, the transfer of a painting executed on wood to a new canvas support is scarcely satisfactory, since the original character of the work is thereby altered. Such an operation should be undertaken only in extreme cases, when a plywood expert is not available. In fact, plywood is, for the time being, the only material that will give satisfactory results for the transfer of panel paintings.

Throughout all these operations, care must be taken to ensure that the light tone and the cohesion of the priming are in no way changed.

Operation.

250. — The actual method of transfer (described in detail in Chapter XV) calls for certain preliminary precautions of paramount importance. Afte carefully determining the composition of the paint layer, a protective sheet should be laid over it, composed of a substance sufficiently transparent to permit of a constant inspection of the layer during the operation. For this purpose, a sheet of transparent Japanese paper may be used, stuck on to the paint layer with starch glue, if the paint is not sensitive to water. Otherwise, and even in any case, for safety's sake, the paint layer may be isolated by a coat of varnish. Successful use has also been made of strips of transparent adhesive film (rubber adhesive) similar to the transparent tape used for surgical dressings; these strips should not, however, be left on the paint for more than a week; neither should they be allowed to dry, as they shrink in the process. It is also possible to use resin adhesives, as for relining (see Chapter XV, §§ 199 *et seq.*)

IV. Other Deteriorations

Dark Streaks.

251. — The appearance of dark streaks on the surface of a picture, parallel to the grain of the wood panel, is often due to the penetration of resinous or

acid elements exuded from the pores of the wood through the priming. This generally occurs because the priming has failed to afford adequate protection.

There is scarcely any effective remedy against this form of deterioration; there are several famous paintings in which, not dark streaks, but actual resin appears at regular intervals, according to the hygrometric conditions prevailing in the gallery. As a rule, all that is done is to remove the resin, to prevent it from damaging the adjoining areas of the painting.

According to circumstances, consideration may be given to adopting the radical remedy of transferring the picture in its entirety, with a complete renewal of the priming.

Local and accidental deterioration.

252. — Accidental damage — knocks, scratches, etc. — does not admit of universally appropriate treatment. Holes can be filled with wood paste, composed of very fine sawdust mixed with cellulose. (See above for the treatment of deterioration of this kind.)

Insect attack, mould, etc.

— (See Part A of this chapter.)

CHAPTER XVII

OTHER SUPPORTS

Besides wood and canvas, the conservator occasionally meets with paintings on supports consisting of parchment, paper, various composition boards, metal, stone and plaster. It will suffice here to outline the chief characteristics of each. The International Museums Office will, in due course, publish articles relating to paper supports (prints, drawings, manuscripts, etc.), and to mural painting which involves the study of plaster and mortar. (For these two types of support, see the appended *Bibliography* for references to the articles which have already appeared in *Mouseion.*)

Parchment.

253. — Parchment is made of the skins of animals by removing the hair and preparing the surface by abrasives until it is smooth and in a suitable condition for painting. When wetted, parchment expands and becomes soft and flexible; it shrinks very considerably on drying. The effect of moisture on parchment is to make it cockle and there is no way of removing the folds in the material without softening again with water and stretching uniformly.

Paper.

254. — Paper is made of vegetable fibres which have been thoroughly disintegrated and matted together to form a sheet. Even the best papers which are made from cotton and linen rags are not so strong as parchment, but they do not stretch when wetted to the same extent as parchment and have less tendency to cockle. The strength of paper depends on the length and quality of the fibres and on the excellence of the sizing. Glue size is added to paper in the process of manufacture to prevent the colour from running into the tissue as it would in blotting-paper.

Conservation of Parchment and Paper.

255. — In addition to a marked tendency to deteriorate under the influence of excessive moisture, both parchment and paper are susceptible to attack by moulds and bacteria which weaken the ground and cause staining.

Both materials may be sterilised by exposing them in a chamber for some hours to the vapours emitted by molten thymol; this treatment softens oil paint and varnish but causes no change in watercolour, tempera, miniature (gum) painting or in manuscript matter.

Excessive heating must be avoided in the care of parchment, vellum, etc., because it causes desiccation and embrittlement.

When paper has been attacked by mould, the size is destroyed and the substance weakened; in such cases, sterilisation in itself is insufficient as a method of restoration. The mould growths must be picked off carefully with a brush, after having been moistened, if necessary, with alcohol, and strength restored to the film by re-sizing with clear gelatine solution (1 sheet in a quart of water). (See the methodical study on the Preservation of Prints, Drawings and Manuscripts, by H. J. Plenderleith, in *Mouseion*, Vol. 29-30, pp. 81-104, and Vol. 33-34, pp. 199-226.)

Cardboard.

256. — The many types of cardboard are made by pasting laminated sheets of paper together, sometimes with a layer of paper-pulp incorporated. These boards are subject to the same forms of decay as paper itself; they contain, however, a high proportion of glue, generally of inferior quality, and this glue, in adverse circumstances, is very noxious because of its nutrient properties for micro-organisms. Cardboard is softened by moisture and very easily attacked by fungus, so that a painting may suffer as a result of the intensive decay of the support. In such cases, it may be easier to soften with water and to remove all excess of paper from the back and then to clean and remount the painting on a card of good quality (or on plywood) than to attempt restoration of the original support.

Plywood.

257. — Plywood, if chosen with care, forms an excellent support for painting. Since each ply of wood is cut around the trunk of the tree and not longitudinally

as in the manufacture of planks, it is important that the surface of the plywood should corresponds to the external surface of the ply as cut from the tree; otherwise, there is a tendency for small cracks to appear when the thin sheet is flattened out. Before painting, therefore, the surface of a plywood panel should always be examined to make sure that there are no such cracks and any wood which does not conform to the specification recommended should be discarded. (For further details, see the sections concerning plywood, etc. in Chapter XVI, §§ 242 *et seq.*)

Synthetic Wood.

258. — A synthetic wooden board is available today which is made from wood that has been disintegrated by steam. The cementing material of the timber (lignin) is thus removed. The wooden fibres are then matted together and compressed, lignin being used as adhesive; in this manner, the wood is reconstituted in the form of a grainless board. It is chestnut brown in colour and does not crack or warp, though large sheets naturally require some form of cradling to prevent distortion.

Metal.

259. — Metal is sometimes used as a ground for paintings, e.g.: copper, iron and zinc, and, more recently, aluminium. The principal feature of the metal ground is its easy conduction of heat and cold, which cause the paint-layer to be subject to more persistent and continuous changes in this respect. Metal panels should, therefore, be hung in positions which are not exposed to heat or to draughts of air, otherwise flaking of the paint is to be expected.

Corrosion may play an important part in the stability of the picture. It is caused by the metal's undergoing chemical action with some acid, alkali or salt. It may be arrested by washing with water, if this is possible, or, if not, by a salve of wax dissolved in turpentine, a little wax being left on the surface in order to localise the effect of any corrosive matter that may remain.

Stone.

260. — Paintings executed on stone are rarely found in collections of easel paintings. Slate has occasionally been used and forms a stable painting surface, characterised, however, by its brittleness and relative weight. Hard non-

porous stones are likewise perfectly stable as painting grounds, and if paint tends to flake from such materials this is probably due to the desiccation of the ground and the comparative absence of keying to the stone. Paint lasts well on marble when not exposed to outside weathering. The same cannot be said, however, of paintings on the more porous stones (sandstone and limestone) as these will always take some time to reach equilibrium conditions in the gallery.

It may require a considerable amount of time for the water in the stone to dry out and, in the meantime, the paint may exhibit a tendency to flake away from the surface. The only steps that one can take are to keep the back of the stone free to "breathe", i.e., it should in no circumstances be impregnated with varnish or enclosed in a frame. In this way, the moisture is encouraged to evaporate from the back rather than through the paint layer.

When salts are present in porous stone, as is usually the case with stones that have been excavated, the problem becomes more difficult, as the salts tend to be drawn towards the more porous surface, where there is greatest evaporation. Crystallisation may take place which will cause flaking or a powdery form of disintegration. In such cases, the problem is more in the province of the restorer of antiquities than in that of the conservator of paintings.

Frescoes on show in museums.

261. — The most delicate period in the life of a fresco that has been removed to a picture gallery is during the time immediately following its introduction into the collection—the time during which it is becoming acclimatised to the new conditions of temperature and humidity. And here, once more, the general principle is illustrated that a gradual change to new conditions is likely to do much less harm than one which is abrupt and which is carried out without due foresight and consideration for the facts. A transferred fresco which has been consolidated with plaster should never be immediately framed and exhibited in the gallery; on no account should it be built into the structure of the building. It should be freely exposed in a cool part of the studio so that drying takes place slowly until the condition of equilibrium is reached. A test may be made of the residual moisture by holding a sheet of clear gelatine against the surface with a strip of adhesive tape and observing whether there is any cockling in the gelatine.

If the fresco is to be framed, whether glazed or not, it should never be entirely

enclosed in a box. The back should be adequately supported by cross battens of wood and a piece of raw cloth (unprimed) stretched over them to exclude dust and insects. Green "Willesden canvas" may be used for this purpose, or the fabric may be made proof against moths and other parasites by painting it with a solution of copper naphthenate in paraffin oil. When a fresco has been transferred to canvas it is much thinner and the question of drying out is not of the same urgency. In such cases, it is important to ensure that the canvas is not allowed to become too tight on the stretcher, because the fresco ground is in no sense flexible and would be torn, with consequent flaking of the paint.

The general problem of the conservation and restoration of mural paintings was dealt with in a special study published in Vol. 39-40 of *Mouseion*. In this chapter, therefore, we have confined ourselves to giving a few elementary recommendations for the guidance of conservators who have frescoes in their collections.

APPENDICES

PRACTICAL RECOMMENDATIONS

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ALPHABETICAL INDEX

The practical recommendations given in this section of the manual merely state the elementary precautions with which a museum staff responsible for the conservation of collections of works of art should be familiar. They should therefore be regarded not as the conclusion to this volume but as a note that can be consulted by a museum staff and even by the general public, in whatever form the curator may consider most appropriate.

As regards the BIBLIOGRAPHICAL REFERENCES, *we wish to point out that they are confined to the works so far published by the International Museums Office. We are, of course, fully aware that extremely valuable studies have appeared elsewhere on the subject of preserving and restoring works of art, and if we have limited our enumeration to articles published in the review* Mouseion *it is because we were thus certain of placing at the reader's disposal documentary material that would be easily accessible. If, moreover, we had extended our bibliography to the whole of this literature, we should have been obliged not only to make what might have been an arbitrary selection, but also to amplify our references to such an extent that they would have been less practical for the purposes of consultation. Such a method would, in fact, have been contrary to the spirit of this manual, which is intended only as a guide. Lastly, although the basic studies that have been published elsewhere are not mentioned in this appendix, they are amply cited in the various articles referred to in our bibliography.*

In any case, it is still our intention to compile a comprehensive bibliography on the subject at a later date.

PRACTICAL RECOMMENDATIONS (*)

The deterioration to which paintings are subject may be attributed not only to the natural changes which occur in the course of time or as the result of organic defects in the materials employed, but also, in some instances, to careless treatment and handling and, more particularly, to certain reactions caused by surrounding conditions.

The different component parts of a picture (support, priming, the paint layer and the protective coating of varnish) are, in fact, extremely sensitive to variations in temperature and atmospheric humidity.

In the case of pictures painted on wood, it is common knowledge that moisture causes the panel to expand, while a dry atmosphere causes it to contract. For canvases, this phenomenon is reversed. Since, however, the paint layer is less elastic than the support, it is unable to adapt itself to these variations and consequently cracks and frequently becomes separated from the panel or canvas as the case may be.

It sometimes happens that, under the influence of hygrometric factors, the size used in the preparation of the priming loses its adhesive power, with the result that the paint layer becomes detached, blisters and flakes.

Very often, these risks of deterioration can be reduced by a good protective coating and favourable atmospheric conditions. As soon as the first symptoms of deterioration appear, and these are easily detected if a careful and constant watch is kept over the picture, it is indispensable that the advice of a technical expert attached to the science laboratory of a big museum should be sought and every possible guarantee obtained before entrusting the defective painting to a restorer. Such precautions and guarantees are necessary both in the case of a merely superficial cleaning of the picture and in operations of a more serious nature such as the removal of varnish or alterations to the support.

In practice, these general principles may be set forth in the following order:

(*) Circular issued by the International Museums Office, 1933.

I. Hygiene of premises

Variations in the hygrometric ratio.

First and foremost, frequent and sudden changes in temperature and humidity must be avoided. Changes in temperature, which, in themselves, may have but little effect on paintings, play an important part as determining factors of the degree of moisture attained. For this reason, special consideration must be given to the system and organisation of heating and ventilation in museum rooms, in order that this relation between humidity and temperature may remain as constant as possible.

Heating.

Stoves should, wherever possible, be placed outside the exhibition rooms; under no circumstances should paintings be exposed to the direct radiation of heat. Paintings will then be less suddenly affected by variations in temperature and, at the same time, the dust raised by the stoking of the stoves will be avoided.

In the case of *hot-air heating systems*, care must be taken to provide the inlets with filters to obstruct the passage of dust and ensure the maintenance of a suitable degree of moisture. No paintings should be hung near a hot-air inlet, for the latter always sets up a circulation of air within a given space, producing distinctly harmful results and attracting towards it a certain quantity of dust in suspension about the room.

Heating by radiators inevitably causes considerable dryness of the surrounding atmosphere, a dryness that can never be compensated by saturators, the effect of which in a museum room is entirely illusory. No central heating plant should be envisaged without an accompanying and appropriate apparatus for ensuring proper humidification. Radiators should also be encased in order to prevent direct radiation of heat. Lastly, pictures must not be hung immediately above circulating pipes or radiators.

Low-pressure hot-water systems are always preferable to steam-heating, as they are equipped with bigger radiators, kept at a lower temperature, permitting of a more uniform distribution of heat; moreover, when the heating is shut off, the temperature falls less suddenly than is the case with steam-heating.

It is to be noted that the mere presence, in exhibition galleries, of hangings, curtains and upholstered furniture, is an appreciable factor from the point of view of compensating variations in temperature.

Whatever system of heating may be adopted, care must be taken to avoid too sudden fluctuations of temperature, as these inevitably lead to changes in the hygrometric ratio; consequently, throughout the whole of the heating period, temperature should be maintained at a constant level *both day and night*. In this connection, seasonal heating, for example by steam pipes, should be excluded. The maintenance of a constant temperature is equally desirable for water-colours, drawings, etc., although it is true that this class of exhibits is less subject to deterioration caused by that dryness which invariably plays such havoc with canvases and painted panels.

Any modification made in the heating plant of a museum should be accompanied by a close examination of the paintings exposed to the new conditions, so that the risks involved by such modification may be obviated in time.

Ventilation.

Care must be taken to avoid any system of ventilation likely to produce excessive fluctuations in the ratio of humidity to temperature.

Ventilation by means of windows should be prohibited in all cases where the air can be renewed by other means, such as doorways, air inlets and exhausts, etc.

Draughts are always a menace to panel paintings.

An endeavour should therefore be made to ascertain what draughts may be set up in a museum room and steps taken to check them; very simple devices, such as the hanging of a light cord or tape at various spots along the walls or partitions on which the paintings are hung will immediately detect draughts. Draughts can be considerably attenuated by fixing hangings over the entrances to rooms.

Cleaning of rooms.

In rooms where the circulation of visitors is particularly intense, the floors should be covered by rubber matting or any other material harbouring and creating the minimum of dust. Wilton carpet, which has the great drawback of collecting and raising dust, unless suitable cleaning apparatus is available, has, on the other hand, the advantage of assisting in regulating the degree of atmospheric humidity.

Rooms should be cleaned by vacuum cleaners or by sweeping with moistened sawdust; ventilation, when permanent ventilating plant has not been installed,

should never be effected *before* the rooms have been cleaned and dusted, in order that the dust may not be transferred from the floor to the picturos.

Aspect of rooms.

In the case of oil-paintings and tempera paintings, which can be shown in rooms with a southern aspect, care should always be taken to avoid the direct rays of the sun, which soften the paint layer and cause a dangerous desiccation of the supports. Light should, preferably, be attenuated by means of blinds, the thickness of which rather than the tint minimises the dangers of over brilliance. These blinds should be fitted in such a way as to harbour the least possible dust. In the summer, it is advisable to whitewash the outside surface of ceiling lights; this measure reduces glare and helps to diffuse the light.

For this class of paintings also, lack of light, which in the long run causes the pigments to turn yellow (oil medium), should be avoided as much as possible.

The same does not apply to water-colours, guazzo and drawings, which should be hung counter-light, preferably in rooms with a north light, and never permanently exposed.

Fire prevention.

Every possible precaution should be taken against risk of fire: inspection of heating plant, lighting conduits and wiring, plumbing, etc. A plan should be drawn up, systematically and briefly showing the action to be taken in case of an outbreak of fire: closing of all air-inlets, taking down of pictures, the position of which against walls and partitions makes them a particularly easy prey, etc. The type of fire-extinguisher supplied should be very carefully considered, as the majority of those on the market can cause serious damage to pictures.

Smoking should be strictly prohibited in all parts of the buildings.

II. Dusting and Cleaning of Pictures

The dusting of pictures should be regarded as an exceptional measure; it should, however, invariably be done with the aid of a feather-duster or a very soft brush and the surface of the pictures should be carefully and lightly touched. Under no circumstances should the surface of paintings be rubbed.

Pictures should be hung with a slight tilt forwards to reduce the depositing of dust to a minimum.

If a picture seems to need more extensive cleaning, the curator should immediately take the necessary steps.

In all cases, treatment wrongly regarded as harmless, such as washing with soap and water, must be strictly forbidden; the effects of such injurious methods do not manifest themselves immediately, but, as a matter of fact, water can find its way, by capillary attraction, into the smallest fissure and crack of the paint layer and reach the priming, sooner or later causing separation and blistering, not to mention the damage which may be done to the varnish.

Frames should be inspected at regular intervals for the detection of parasites which frequently attack them and the propagation of which may imperil the panels themselves.

III. Exhibition Material

In the framing of pictures, care should be taken to avoid all methods involving vibration and shock (nailing, for example) or likely to disturb the support in any way. Preference should be given to the use of steel clips fixed by means of screws. A certain play should be left in the rebate of frames.

Pictures should never be hung directly against a wall or partition; in all cases, cleats should be provided to ensure a free air-space at the back of the support.

When a museum building is situated on or near a main road with traffic, measures must be taken to prevent the vibration of walls from being communicated to the pictures; this can be done by adopting a system of hanging with flexible hooks driven into rubber plugs, for example.

Protective glazing necessitated by the condition of certain exhibits or by the quantity of injurious matter in suspension in the surrounding air, should be fixed in such a way that it can easily be removed from the front without disturbing the painting. Glass which shows properties of crystallisation or manifestly of a kind to retain moisture or favour the formation of mildew should be immediately removed and replaced by new material.

IV. Restoration

Whatever may be the nature of the deterioration calling for intervention, it is recommended that no action should be taken without the previous advice of a laboratory attached to one of the leading museums. If restoration proves to be necessary, the condition of the picture before and after restoration should

be photographically and radiographically recorded; a statement should also be prepared showing accurately and in detail what work has been done, with mention of the person responsible for the restoration (restoration index).

The transfer of a painting to a new support should be allowed only when every other measure of a less radical nature is recognised as inadequate and when all the external factors which may have occasioned the deterioration have been examined and eliminated. The efficacy and extent of restoration would in numerous cases be reduced if the reconditioned picture were again to be placed in the same surroundings and conditions as those which caused the damage.

When, after obtaining qualified advice, retouching is deemed indispensable, this work should be visible to the naked eye. No circumstances can justify the concealment of any portion whatsoever of the original painting.

Retouching should always be easily removable.

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mation of attribution to Raphael. — Radiographic examination. — Transfer. — Removal of repaints and consolidation of damaged areas.

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Transport de fresques orientales sur de nouveaus supports (George L. Stout and Rutherford J. Gettens), Vol. 17-18, pp. 107-112, illus.

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Restauration d'un relief d'argile peint (George L. Stout), Vol. 29-30, pp. 105-112, illus.

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Le transfert sur un nouveau support d'une aquarelle sur parchemin (Paul Hubner), Vol. 31-32, pp. 179-181.

Description of transfer operations: consolidation of the paint layer, reduction of blisters and impermeabilisation; application of layers of paper on the front, scraping of the parchment, transfer to a prepared cardboard support and removal of the protective covering.

TABLE OF COLOURS

The following table of colours may be used for reference in the study of paintings and in the choice of materials for restoration.

The range of pigments given in the table is confined to those which are used today or which are known or presumed to have been used in the past for easel paintings.

As the source of many of the pigments used in tempera painting in mediæval times cannot, at this stage, be determined with exactitude, and as it is likely, in some cases at least, that they derive from those colouring matters used for years previously in the illumination of manuscripts, some of the latter colours have been included.

The list does not pretend be comprehensive in regard to the comparatively modern lake colours whose number is legion.

Difficulties of classification arise in the case of different pigments sharing the same name, and also in the case of modern substitutes for a pigment to which the traditional name has been given though differing in chemical composition and probably in permanence. In the former case, the names are given between inverted commas; in the second, the reader will be guided by the data concerning the composition of the pigments and the relevant chemical formulæ.

WHITE

USUAL NAMES				COMPOSITION	USE IN PAINTING	ALTERATION AND RESTORATION
English	*French*	*German*	*Italian*			
White Lead Flake White Cremnitz White	Blanc de plomb Blanc d'argent Céruse	Bleiweiss Kremserweiss	Biacca Bianco d'argento Cerussa	Basic carbonate of lead. 2 $PbCO_3$, $Pb(OH)_2$ perhaps with barium sulphate $BaSO_4$	From earliest times to today. Great covering power, density and brilliant whiteness. Very poisonous. Incompatible with verdigris and orpiment and, in general, with impure colours containing sulphur or selenium.	Blackened by sulphuretted hydrogen, not much in oil, but speedily in aqueous media. *Restoration:* Watercolour, by exposure to hydrogen-peroxide vapour; oil-colour, by scraping to remove blackened surface.
Zinc White	Blanc de zinc	Zinkweiss	Bianco di zinco	Zinc oxide. ZnO	From 1787 to today. Minerals containing zinc may possibly be found present as impurities in colour mixtures from earliest times (Zincblüte).	
Titanium White	Blanc de Titane	Titanweiss	Bianco di titanio	Titanium oxide. TiO_2 perhaps with barium sulphate $BaSO_4$	From 1870 to today. The commercial preparation dates from about 1850. Great covering power, brilliantly white and non-poisonous. Not much used in easel painting. Good substitute for white lead in tempera.	
Bone White	Blanc d'os	Beinweiss		Calcined bones, mainly calcium phosphate.	Used in tempera. Compatible with verdigris and orpiment (see white lead, above).	
Chalk	Craie	Kreide	Creta	Calcium carbonate. $CaCO_2$	From earliest times to today. For tempera, pastel, preparing painting grounds and as a filling material.	Decomposed by acids.
Lime putty	Lut	Gelöschter Kalk		Stiff slaked lime. Practically $Ca(OH)_2$	For fresco painting.	Decomposed by acids.
Carbonated lime putty St John's White	Blanc de Saint-Jean	Johannesweiss	Bianco sangiovanni	Practically $CaCO_2$	Mainly for fresco painting. Dense and brilliant. Referred to by Cennino Cennini (1437).	Decomposed by acids.
Gypsum Lightspar	Plâtre—gypse	Gips	Gesso	Calcium sulphate. $CaSO_4$—$2H_2O$	From earliest times to today. For tempera, pastel, preparing painting grounds and as a filling material.	
White Clay Kaolin. China or Pipe Clay. White bolus	Kaolin. Blanc de Chine Terre de pipe	Kaolin Pfeifenton Pfeifenerde	Caolino Terra da porcellana	Derived from the decomposition of feldspar. Mainly aluminium silicate.	From earliest times to today. For tempera, pastel, preparing painting grounds and as a filling material. Also used as a ground for gold.	
Barium White Heavy spar	Blanc de baryte Blanc fixe	Barytweiss Permanent weiss	Bianco di barite	Barium sulphate. $BaSO_4$	From second half of XIXth century to today.	
Lithopone	Lithopone	Lithopon	Litopone	Zinc sulphide with some oxide and barium sulphate.	From 1847 to today. For oil, tempera and pastel, and especially for decorator's paints as a substitute for white lead. Non-poisonous. Does not darken. Not much used in easel painting.	

USUAL NAMES				COMPOSITION	USE IN PAINTING	ALTERATION AND RESTORATION
English	*French*	*German*	*Italian*			
Ochres and Siennas (Ochre — Mars yellow)	Ocres et siennes (ocre jaune — jaune de Mars)	Ocker und Sienna (Gelber Ocker—Marsgelb)	Ocra—Gialla	Earths coloured by iron oxides. Mars yellows are synthetic laboratory products.	From earliest times to today.	Slight darkening in oil.
Cadmium yellow	Jaune de cadmium	Kadmiumgelb	Giallo di cadmio	Cadmium sulphide. CdS.	From 1818 to today.	Mixtures with pigments containing lead or copper darken.
Naples yellow	June de Naples	Neapelgelb	Giallo di Napoli Giallorino	Lead antimonate. $Pb_3(SbO_4)_2$	From 1700 to today. The powdered pigment has abrasive properties. Must not be ground with steel spatula in the absence of binding medium.	Darkened by sulphuretted hydrogen. Modern substitutes contain cadmium yellow, ochres and white.
Chrome yellow	Jaune de chrome	Chromgelb	Giallo di cromo	Neutral or basic chromates of lead. $PbCrO_4$	From 1809 to today.	Darkened ny sulphuretted hydrogen. *Restoration:* Watercolour by hydrogen-peroxide vapour; oils by scraping.
Zinc yellow	Jaune de zinc	Zinkgelb	Giallo di zinco	Zinc chromate. $ZnCrO_4$	From 1809 to today.	Slightly soluble in drying oils.
Barium yellow Permanent yellow Yellow ultra-marine	Jaune de baryum Jaune permanent Jaune d'outre-mer	Baryumgelb	Giallo di barite	Barium chromate. $BaCrO_4$	From 1809 to today.	
Strontium yellow	Jaune de strontium	Strontiumgelb	Giallo di stronziana	Strontium chromate. $SrCrO_4$	From 1809 to today.	
Cobalt yellow	Jaune de cobalt	Kobaltgelb	Giallo di cobalto	Cobalt potassium nitrite. $2CoK_3(NO_2)_6,3H_2O$	From 1848 to today.	
Massicot	Massicot	Bleigelb	Massicot Giallorino	Lead oxide. PbO	From earliest times to XIXth century.	Darkens. Oil and tempera may be treated with hydrogen-peroxide scraping if necessary.
Orpiment King's Yellow	Orpiment	Auripigment	Orpimento	Sesquisulphide of arsenic. As_2S_3	From earliest times to XIXth century. Very poisonous.	
Mosaïc-gold	Or mussif	Mosaïkgold	Oro musivo	Golden-yellow crystalline stanic sulphide. SnS_2	From XIVth to XVIIth century. Used to some extent for imitating gilding in panel painting.	
Antimony sulphides	Sulfures d'antimoine	Antimonsulfid	Solfuri di antimonio	Sb_2S_3	As substitute for gold, XVIth-XVIIth centuries.	

YELLOW (Contd.)

USUAL NAMES				COMPOSITION	USE IN PAINTING	ALTERATION AND RESTORATION
English	*French*	*German*	*Italian*			
Indian yellow	Jaune indien	Indischgelb	Giallo indiano Purrea	Magnesium euxanthate made from urine of cows fed on mango leaves from Monghyr, India.	Has been used mainly for the illumination of manuscripts.	Durable when pure but often adulterated, e.g. with chrome yellow. Lake pigments are used as substitutes today under the same name.
Bile yellow (Lombard gold colour)	Jaune de bile	Gallgelb			Orpiment substitute. A medieval colour used mainly for illumination.	Bleaches and sometimes darkens.
Saffron	Safran	Safran	Zafferano	Dried stigmas of the saffron crocus (crocus sativus).	A medieval colour used mainly for illumination.	Easily bleached by light.

The principal medieval yellows, apart from gold, are orpiment (yellow sulphide of arsenic) and ochre, giallorino (probably massicot—lead oxide—in the majority of cases), mosaic gold, saffron, buckthorn and weld. (Cf. Thompson: *Materials of Medieval Painting*).

RED

USUAL NAMES				COMPOSITION	USE IN PAINTING	ALTERATIONS AND RESTORATION
English	*French*	*German*	*Italian*			
Burnt red ochre and red earth colour. Burnt Sienna. English, Indian, Pompeian, Persian or Venetian Reds. Mars Reds. Pozzuoli Earth. Santorin Earth "Sinopis", etc.	Couleurs d'ocre rouge brûlée et de terre rouge. Terre de Sienne brûlée. Rouge d'Angleterre (colcathar, caput mortis). Rouges indien, pompéien, de Perse, vénitien. Rouges de Mars. Terre de Pouzzolles. Santorin, « sinople », etc.	Gebrannter lichter Ocker; rote Erden, geb. Sienna; Englisch, Indisch, Pompejanisch, Persisch oder Venetianisch rot; Mars Rote; Pozzuoli Erde; Caput mortuum, etc.	Ocra rossa—Rosso inglese	Earths coloured by iron oxides, either natural red ochres or burnt ochres occurring in volcanic districts or synthetic compounds.	From earliest times to today.	Sometimes blackened by exposure to the sun. No satisfactory treatment known.
Cinnaber Vermilion	Cinabre Vermillon	Zinnober	Vermiglione Cinabro Rosso chinese	Mercuric sulphide. HgS.	From earliest times to today. Cinnabar was gradually replaced by synthetic vermilion.	The blackened surface may be removed by scraping.

YELLOW (Contd.)

RED

USUAL NAMES				COMPOSITION	USE IN PAINTING	ALTERATION AND RESTORATION
English	*French*	*German*	*Italian*			
Cadmium red Serenium red	Rouge de cadmium Rouge de selenium	Kadmium rot	Rosso di cadmio	Cadmium selenide with perhaps a little cadmium sulphide. CdSe with CdS	From 1817 to today.	Mixtures with pigments containing lead or copper darken.
Chromium red	Rouge de chrome	Chromrot	Rosso di cromo	Basic lead chromate. Pb_2CrO_5	From 1809 to today.	Blackened by sulphuretted hydrogen. Turned yellow by acetic acid.
Minium Saturn red Red lead	Minium Rouge de Saturne Rouge de plomb Mine rouge	Mennige Bleirot	Minio Rosso di Saturno Rosso di piombo Rosso di Parigi	Lead oxide. Pb_3O_4	From earliest times to today.	Blackened by sulphuretted hydrogen. *Restoration:* As for blackened white lead (see above).
Realgar	Réalgar Arsenic orange	Realgar	Realgar	Arsenic sulphide. As_2S_2	From earliest times to XIXth century. Very poisonous.	Converted to orpiment (yellow) in bright sunlight. *Restoration* of colour by scraping.
Thyrrhian Purple Shellfish red	Pourpre de Tyr	Thyrrhenischer Purpur	Porpora	From Murex etc.	Give a wide range of colour: red to black, often with a bluish tinge. From 1st century to medieval period, for encaustic painting and illumination.	
Lichen red Archil	Roccelle Orseille		Oricello	From the lichen. *Roccella tinctoria*	Reddish purple. Used in the middle ages mainly for manuscript illumination.	
(*Cochineal*) Crimson lake Carmine, Indian lake	(Cochenille), Carmin Laque carminée Rouge écarlate Laque indienne	Cochenille Karmin Indischer Lack	(*Cocciniglia*) Rosso di cocciniglia Acido o Carminio (lacca) Acidio carminicio	Cochineal.	Crimson.	Not particularly durable. Tends to become pale.
Ceylon brazilwood	Bois du Brésil	Brasilholz	Legno rosso Legno del Brazile	Essential dyestuff : Brasilin. $C_{16}H_{14}O_5$	Medieval pigment used for manuscript illumination.	
Madder	Laque de garance	Krapplack	Robbia Garanza	Essential dyestuff : Alizarin. $C_{14}H_6O_2(OH)_2$	XIVth century. From XVIIth century to today.	Tends to become pale.
"Cynople"	« Sinople »			A mixed pigment containing lac, brazil, cochineal, etc.	Medieval pigment used for manuscript illumination.	Tends to become pale.
Dragon Blood	Sang de dragon	Drachenblut	Sangue di drago	Brownish red gum-resin.	For lacquering gold, and as a pigment in medieval times for manuscript illumination.	

The principal red pigments of the middle ages are the red ochres, orange lead, vermilion (replacing natural cinnabar), kermes and grain (chiefly in the form of lakes made from the shearings of cloths dyed with them), lac, brazil, madder (chiefly in combination with lac and grain and brazil in the compound cynople), and dragon's blood. (Cf. Thompson: *Materials of medieval painting.*)

USUAL NAMES				COMPOSITION	USE IN PAINTING	ALTERATION AND RESTORATION
English	*French*	*German*	*Italian*			
Natural ultramarine Lapis lazuli	Outremer naturel Lapis lazuli Bleu d'azur	Natürliches Ultramarin Lasurstein	Oltremare naturale Lapis lazzuli	Compound silicate of aluminium, calcium and sodium, containing sulphur. Mineral.	From earliest times to XIXth century.	Decomposed by acids.
Artificial ultramarine	Outremer artificiel	Synthetisches Ultramarin	Oltremare artificiale	*Ditto*—synthetic. A furnace product	From 1825 to today. Cheap ultremarines are unreliable.	Decomposed by acids. Incompatible with colours containing copper.
Azurite	Azurite	Bergblau Kupferlasur	Azzurite Azzuro di Montagna	Basic carbonate of copper. Mineral. $CuCO_3Cu(OH)_2$	From earliest times to XIXth century. Best when not finely ground.	Darkened by excess of oil, which is speedily yellowed, the pigment becoming green. Incompatible with pigments containing sulphur.
Smalt	Smalt Bleu de Smalt	Smalte	Smalto	Powdered cobalt glass; a silicate of potash and cobalt.	From middle of XVIth century to today.	Unsuitable for use in oils.
Prussian blue Antwerp blue	Bleu de Prusse Bleu de Paris	Preussisch Blau Berliner Blau	Azzuro di Prussia Azzuro di Berlino	Ferric ferrocyanide. $Fe_4(Fe(CN)_6)_2$ Antwerp blue and milori blue are of related composition.	From 1704 to today. Used with chrome yellow to make the mixed greens called chrome, cinnabar or Brunswick greens.	Turned brown by alkali. Watercolour mixtures with zinc white bleach in sunlight but recover in the dark.
Cobalt blue	Bleu de cobalt Bleu de Thénard	Kobaltblau	Azzuro di cobalto Oltremare di cobalto	A furnace product made by beating cobalt salts with clay.	From 1777 to today.	
Cerulean blue	Bleu ceruleum ou céruléen Bleu céleste	Coeruleum	Ceruleum Bleu celeste	A furnace product made by heating cobalt salts with tin oxide.	From 1805 to today.	
Monastral blue	Bleu monastral	Monastral Blau		A stable organic complex containing copper in non-reactive combination.	Introduced in 1935. A good substitute for Prussian blue in oil colour.	
Copper-ammonialime blues	Bleus à base de cuivre, ammoniaque et chaux	Kupferblau	Azzuri cupro-ammoniacali	Many medieval recipes.	A widespread substitute for ultramarine and azurite in the middle ages.	Tends to become green through loss of ammonia.
Indigo	Indigo	Indigo	Indigo	From *Indibofera tinctoria.*	From earliest times to the XIXth century.	Not permanent in oils, but has resisted well in paintings by Franz Hals.
Woad	Guède	Waid, Pastel, Färberwaid	Guado Pastello	From *Isatis tinctoria.*	From earliest times to the XVIIth century.	Fades.
Turnsole	Croton des teinturiers Crozophore tinctoriale	Krebskraut	Tornasole in pezza o di Provenza	From *Crozophora tinctoria.*	From XIIth to XVIIth century.	Fades.
Egyptian blue	Bleu d'Egypte	Egyptisch Blau	Bleu Egiziano	A glass frit containing copper. CaO. CuO. $4SiO_2$	Used in antiquity, in Egyptian, Greek and Greco-Roman painting and sporadically later.	

USUAL NAMES				COMPOSITION	USE IN PAINTING	ALTERATIONS AND RESTORATION
English	*French*	*German*	*Italian*			
Ultramarine violet	Outremer violet	Ultramarin Violett	Oltremare violetto	See artificial ultramarine. By increasing the temperature of the furnace, a blue-violet product is obtained.	From 1840 to today. Useful in fresco paintings; poor tinctorial value in oils.	More stable to acids than ultramarine blue.
Cobalt violet	Violet de cobalt	Kolbaltviolett	Cobalto violetto	Compound of cobalt oxide and clay, with phosphoric and arsenic acids. Furnace product.	From about 1859 to today. A bright transparent violet. Permanent.	
Manganese violet Mineral violet Nuremberg violet	Violet de manganèse Violet minéral Violet de Nuremberg	Manganviolett Mineral-oder Nürnberg-Voilett	Violetto di manganese Violetto minerale Violetto di Norimberga	Phosphate of manganese.	From about 1868 to today. A dull-violet pigment. Permanent.	
Tyrian purple	Pourpre de Tyr	Tyrrhenisch Purpur	Porpora di Tiro	From a mollusc found in the Mediterranean (genus Purpura or Murex). Dibromic indigo, which forms a large proportion of the colouring matter, can be made synthetically. See shellfish reds.	From earliest times to today. (See note on shellfish reds.)	
Purple of Cassius	Pourpre de Cassius	Cassius Purpur	Porpora di Cassio	Purple-coloured body obtained from tin and gold chlorides.	Used in middle ages for manuscript illumination; today only in the ceramic industries.	
Turnsole purple	Pourpre des des teinturiers			See turnsole blue. The alkaline extract of *Crozophora* is purple.	Used in medieval painting.	
Lichen purple	Pourpre de lichen			See lichen reds.	Used in medieval painting.	

VIOLET AND PURPLE

USUAL NAMES				COMPOSITION	USE IN PAINTING	ALTERATION AND RESTORATION
English	*French*	*German*	*Italian*			
Green earth (Bohemian and Veronese, Venitian green	Terre verte (vert de Bohème, « Vert Véronèse», vert céladon	Seladon grün	Terra verde	Earth coloured with iron silicates.	From earliest times to today. Light bluish grey to dark brownish olive. Much used in early Italian painting.	
Malachite Mountain Green	Vert malachite Vue de montagne	Berggrün Azurgrün Malachit	Malachite Verde minerale Chrysocamma Verde di montagna Verde di rama	Basic carbonate of copper. Artificial carbonate of copper. $CuCo_3$, $Cu(OH)_2$	From earliest times to today.	Mixtures with pigments containing sulphur darken. Decomposed by acids.
Verdigris	Vert de gris	Grünspan	Aerugo	Basic acetate of copper and various mixtures. Salt green contains also chloride; Rouen green contains also copper soap. $2Cu(CH_3COO)_2$. $Cu(OH)_2$. $5H_2O$	From earliest times to the XIXth century.	Mixtures with pigments containing sulphur darken.
Scheele's green Mineral green	Vert de Scheele	Scheelesgrün Schwedischgrün	Verde di Scheele	Copper hydrogen arsenite. $CuAsO_3$, CuO. $2H_2O$	From 1778 to XIXth century.	Mixtures with pigments containing sulphur darken.
Veronese green Schweinfurt green "Emerald green" Paris Green	Vert de Schweinfurt « Vert Véronèse » « Vert Emeraude »	Schweinfurtergrün Deckgrün	Verde di Schweinfurt	Copper aceto-arsenite. $3CuO$, As_2O_3. $Cu(C_2H_3O_2)_2$ "Emerald green" is a related compound.	From 1800 to today. Very poisonous.	Mixtures with pigments containing sulphur darken.
Cobalt green Zinc green Rinnmann's green	Vert de cobalt	Kobaltgrün (Trukisgrün)	Verde di cobalto	Compound of cobalt oxide and zinc oxide. (Furnace product.)	From 1870 to today.	
Oxide of Chromium (matt) « Chrome green »	Oxyde de chrome mat « Vert de chrome »	Chromoxyd grün (matt)	Verde Guignet Verde smeraldo	Sesquioxide of chromium. Cr_2O_3	From 1809 to today.	
Oxide of Chromium transparent or brillant) Viridian	(Oxyde de chrome transparent ou brillant) « Vert émeraude», Vert Guigne	Chromoxydgrün feuring		Hydrated oxide of chromium. Cr_2O_3, $2H_2O$	From 1838 to today.	
Natural green dyestuffs, Sap green, Iris green, Honeysuckle, Nightshade, etc.	Vert de vessie	Saftgrün	Verde di vessica	From Rhamnus berries. The juice of the fruit, flower or leaves of plants, often mixed with alum.	XIVth and XVth centuries. Used mostly for manuscript illumination.	All natural green dyestuffs fade on exposure to light.

USUAL NAMES				COMPOSITION	USE IN PAINTING	ALTERATION AND RESTORATION
English	*French*	*German*	*Italian*			
Raw and burnt Umbers	Ombres naturelles et brûlées	Umbra. Rohe oder gebrannte Braun-eisenerze.	Terra d'ombra	Earth colours containing iron and manganese.	XIth century. From close of XVth century to today. Quick-drying in oils.	Tend to darken in oil painting.
Vandyke brown Cassel brown Cologne Earth	Brun van Dyck Terres de Cassel ou de Cologne	Van Dyck Braun Cassel Braun	Terra di Cassel o di Colonia	Iron oxide with lignite.	From XVIth century to today.	Slightly soluble in drying oils and therefore not quite durable. Turns grey by alkali (see Bitumen).
Prussian brown	Brun de Prusse	Preussisch Braun	Bruno di Prussia o di Berlino	Ignited Prussian blue.	From 1704 to today.	
Verona brown Ignited green earth	Brun de Vérone Terre verte brûlée	Gebrannte grüne Erde	Terra verde bruciata	Ignited green earth.		
Bitumen	Bitume	Asphalt braun	Bitume	A general name for deep brown or black, solid or semi-solid organic substances of indefinite composition obtained naturally or prepared by the distillation of wood, etc.	Not used in the artist's palette today. Used mainly in the XVIIIth and XIXth centuries. English school.	Soluble in oil, in which dries very slowly. Impermanent. Cracks. *Restoration:* Cracks can sometimes be repaired, using a hot spatula; sometimes by embedding the finest cigarette paper in the sticky impasto.
Sepia	Sépia	Sepia	Nero di seppia Bruno di seppia	From the ink-bag of the cuttle-fish. *Eusepia officinalis.*		Reasonably stable in watercolour only.

USUAL NAMES				COMPOSITION	USE IN PAINTING	ALTERATION AND RESTORATION
English	*French*	*German*	*Italian*			
Lampblack	Noir de fumée	Lampenschwarz	Nero fumo d'ombra			
Graphite	Graphite	Graphit	Grafite		XIVth-XVth century.	
Ivory black	Noir d'ivoire	Elfenbeinschwarz	Nero d'avorio		From earliest times, but seems to have been forgotten in the middle ages.	
Bone black (Bone brown)	Noir animal	Beinschwarz	Nero animale			The least stable of the black pigments, because it may contain bitumen.
Charcoal blacks	Noir de charbon animal	Kohlenschwarz				
Mineral black	Noir minéral	Mineralschwarz	Nero minerale	Burnt ochre from foundry.		

USUAL NAMES				COMPOSITION	USE IN PAINTING	ALTERATION AND RESTORATION
English	*French*	*German*	*Italian*			
Charcoal grey	Gris de charbon animal	Kohlengrau				
Davy's grey	Gris Davy	Davy's Grau		Prepared from slate.	From early XIXth century. Transparent and permanent.	

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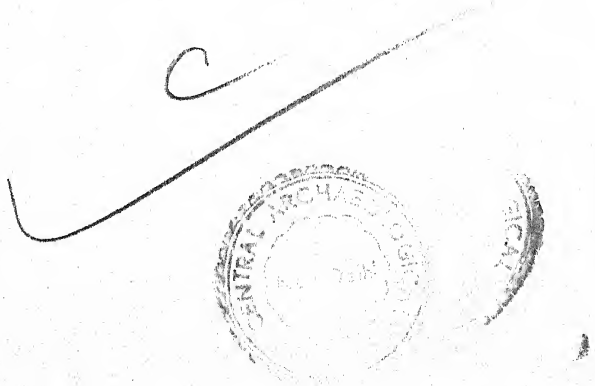
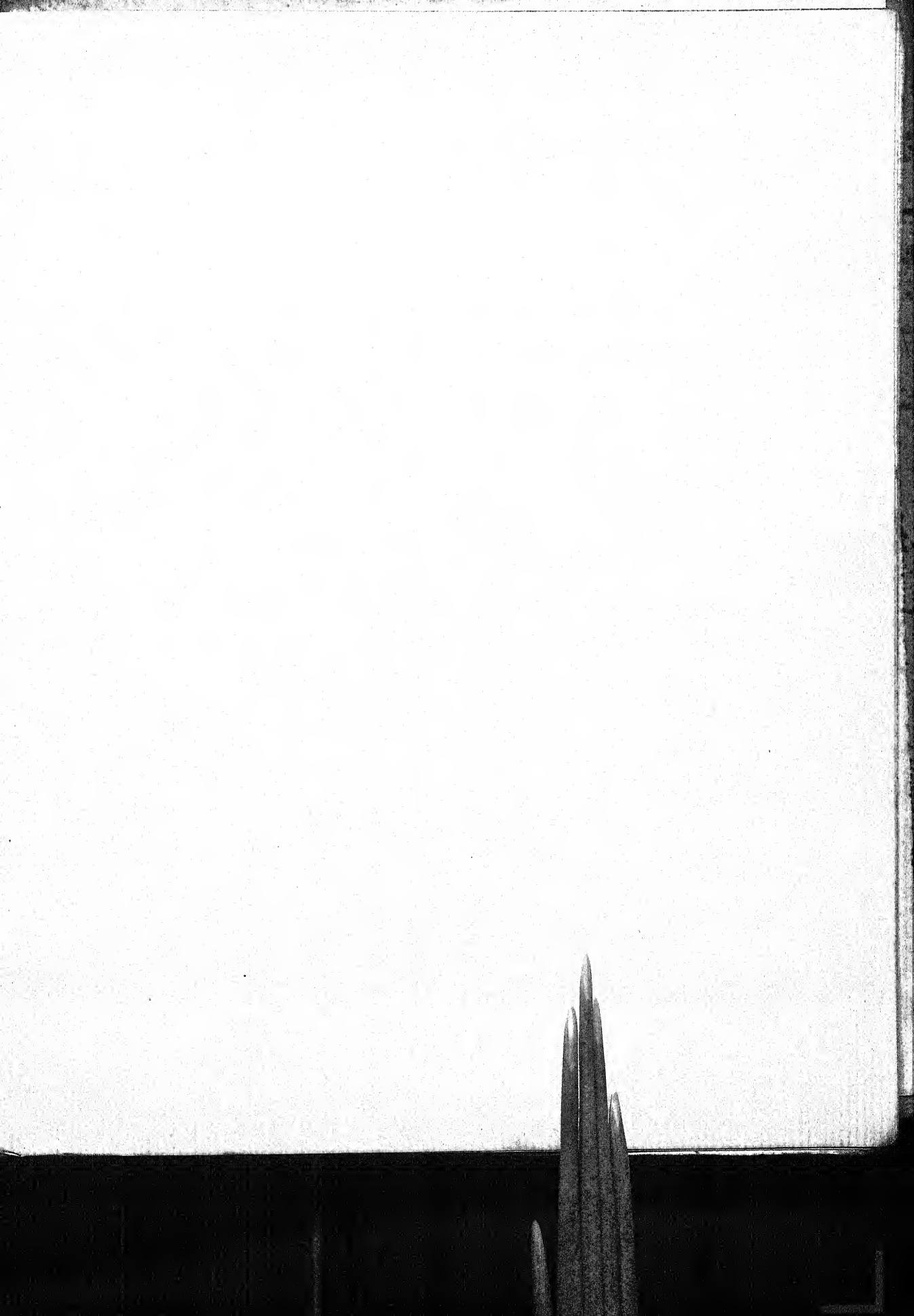
(The figures refer to the sections of the various chapters.)





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